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Memoir upon the Stability of Revetments, and of their Foundations. *By* M. PONCELET, *Chef de Bataillon du Génie.* *Translated from "No.* 13 *du Mémorial de l'Officier du Génie," by Captain* JOHN SANDERS, *Corps of Engineers.*

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Formulas and Tables relative to any kind of Earth or Masonry.

25. The foregoing considerations, and the utility, in practice, of having exact and simple means of solution, have induced me to extend the preceding calculations to the principal cases of application, especially to those which refer to the least and greatest thicknesses of masonry, or to intermediate thicknesses with reference to those of the preceding case.

In consulting, on this subject, the results of experiments, given by various authors upon the densities of earth and masonry of different qualities, we find that the ratio of $p : p'$ of these densities, which rarely reaches unity, is, on the contrary, seldom ever less than $\frac{3}{5}$, or 0.6. If, on the other hand, we refer to the results of observations relative to the slope which loose earth naturally takes, we find the angle α of the slope with the vertical, is between 70°, which is that of fine and dry sand, and 35°, which corresponds to the stiffest and densest earth; in other terms, the coefficient $f = \cot \alpha$, of friction, which can be as high as 1.4 in the latter case, is never less than 0.6 in the former. It is, then, between these extremes that the most ordinary cases in application arise, and for which we propose to calculate a table of the thicknesses of vertical revetments. But, before presenting these results, I

shall briefly indicate the analytical expressions, and methods which serve to establish them, as it might be useful to make them known to those who would be disposed to complete and extend the calculations for other values of the principal given quantities.

26. Still preserving the notations and terms heretofore adopted, and, more especially, continuing to take $\delta = 1.912$, $n = 0$, and the angle $\theta = \alpha$, an hypothesis favorable to the stability, we shall have, (3) since f tang. $\theta = \cot \alpha$ tang. $\theta = 1$,

$$P = \tfrac{1}{2} p (\sqrt{1+f^2} - \sqrt{u^2+f^2})^2 (H+h)^2$$

$$M = \tfrac{1}{6} p \left[1 + 2f^2 + 3u^2 + \frac{2u^3}{f^2} - \frac{2}{f^2}\sqrt{1+f^2}(u^2+f^2)^{\frac{3}{2}}\right]$$

$$(H+h)^3$$

the value of u being furnished by the expression (fig. 1)

$$u = \frac{GH}{BG} = \frac{h'}{H+h} = \frac{a - f(x-m)}{a+1} = 1 - \frac{1+f(x-m)}{a+1}$$

in which

$$a = \frac{h}{H}, x = \frac{e}{H}, \text{ and } m = \frac{b}{H}.$$

We now deduce, in proceeding as heretofore, in number 15, [and in adding $+f^2 u^5 - f^2 u^5$ to the numerator of the fraction,] for the length of the arm of the lever of the pressure P,

$$\frac{M}{P} = \tfrac{1}{3}(H + h - h')(1 + U),$$

in supposing:

$$U = \frac{f^2 u + (2+f^2) u^3 - 2u^2 \sqrt{1+f^2}\sqrt{u^2+f^2}}{f^2 (1-u)(1+u)^2} =$$

$$= \frac{f^2 (1-u) u}{f^2 + (2+f^2) u^2 + 2u\sqrt{1+f^2}\sqrt{u^2+f^2}}$$

and (7), in the place of the equation of equilibrium (n), of number 19,

$$(s)\begin{cases} x^2 + \frac{3}{5}\frac{p}{p'} f(x-m)^2 (x + \frac{1}{2}m) \\ = \frac{\delta p}{3p'f^2}\left[f^2 + 2f^4 + 3f^2u^2 + 2u^3 - 2\sqrt{1+f^2}(u^2+f^2)^{\frac{3}{2}}\right](a+1)^3 \\ = \frac{\delta p}{3p'}(\sqrt{1+f^2} - \sqrt{u^2+f^2})^2 (a+1)^2 [1 + f(x-m)](1+U). \end{cases}$$

27. In the case of fig. 2, or of CG < CH, that is to say, $a < f(x -$

m) and u negative, this equation will be replaced by the following, (9):

$$(t)\quad x=\sqrt{p\,\frac{\delta f^2\,(\sqrt{1+f^2}-f)^2(a+1)^3+(a+fm)^3-f^3m^3}{3f^2\,(p'+ap)}}$$

δ being always equal to 1.912, and $\sqrt{1+f^2}-f$ representing here the value of tang. $\frac{1}{2}\,a$ (6).

28. When the width of the berm is equal to the thickness of the wall, or $m=x$, we shall have likewise (5) and (8):

$$u=\frac{a}{a+1},\text{ and}$$

$$x=\sqrt{\frac{\delta p}{3p'}\left[1+2f^2+3u^2+\frac{2u^3}{f^2}-\frac{2}{f^2}\sqrt{1+f^2}\,(u^2+f^2)^{\frac{3}{2}}\right](a+1)^3}$$

or, by the transformation explained in a following number, (30)

$$(u)\quad x=\sqrt{\frac{\delta p}{3p'}\,\frac{4u^3+f^2(1+3u)}{f^2+2f^4+3f^2u^2+2u^3-2\sqrt{1+f^2}\,(u^2+f^2)^{\frac{3}{2}}}}$$

a formula which answers for all values of u, that is to say, from $a=0$, to a equal to infinity.

29. In order to prepare a table of the values of x, relative to a series of equidistant values of a, and to a certain hypothesis made upon simultaneous values of p, p', f, and m, we shall commence by using formula (t), which gives x immediately, and will be applicable, as has been said, as long as a shall be less than $f(x-m)$; but, as soon as the reverse occurs, it will be necessary to have recourse to equation (s), and to continue on with it indefinitely for the successively increasing values of a.

In principle, we might content ourselves with solving this question by the method pointed out in the 16th and following numbers; and to that end we have drawn up an auxiliary table of the values of the function U, which table will be given hereafter in the second section; but, although the second member of this same equation may be easily calculated by logarithms, nevertheless, this method of solution is so laborious, that it soon became necessary to renounce it in adopting a more expeditious one.

30. Dividing the equation (s) by $\frac{2}{3}\,\frac{p}{p'}\,[1+f(x-m)]^3$, or

$\frac{2}{3}\,\frac{p}{p'}\,(a+1)^3\,(1-u)^3$, since (26)

$$a+1=\frac{1+f(x-m)}{1-u}$$

multiplying afterwards both terms of the fraction

$$\frac{f^2 + 2f^4 + 3f^2u^2 + 2u^3 - 2\sqrt{1+f^2}\,(u^2+f^2)^{\frac{3}{2}}}{f^2(1-u)^3}$$

which will remain as a factor of the second member of the equation, by the sum of all the terms of the numerator taken positively, we shall give to this fraction the form:

$$\frac{4u^3 + f^2(1+3u)}{f^2 + 2f^4 + 3f^2u^2 + 2u^3 + 2\sqrt{1+f^2}\,(u^2+f^2)^{\frac{3}{2}}} = V$$

under which form it will cease to take indeterminate values for $u = 1$, or $a = \infty$, and will thus serve to give the limits of the values of x, or of the thicknesses of demi-revetments (21). In fine, supposing, in order to abridge the substitutions,

$$fx = x', \qquad fm = m',$$

the equation (*s*) will finally become:

$$(s') \quad \frac{\left(\frac{3}{2}\frac{p'}{p} - \frac{3}{2}m' + x'\right)x'^2 + \frac{1}{2}m'^3}{(1-m'+x')^3} = \frac{1}{2}\delta f^2 V = 0.956 f^2 V,$$

and will permit our easily proceeding in the calculation of each of the series of the values of x, corresponding to the different values of a, and to the values arbitrarily assigned to the constants f, m, p, and p'.

31. Having calculated and drawn up, in the first place, an auxiliary table of the values of $\frac{1}{2}\delta f^2 V$, relative to a certain value of f, from $u = 0$ to $u = 1$, increasing by tenths, which will be near enough, we shall calculate from it another of the values of the first member, taking care previously to substitute for $\frac{p'}{p}$ and $m' = fm$, the numbers relative to each hypothesis, and attributing afterwards to x' values increasing by half a tenth, from that which gives a result immediately below

$$0.956\frac{f^2}{(\sqrt{1+f^2}+f)^2},$$

unto that which gives one immediately above

$$0.956\frac{f^2}{(1+f^2)}$$

values which $0.956 f^2 V$, the second member of the equation (s') respectively takes for $u = 0$ and $u = 1$, and which we may be sure not to go beyond, in commencing the substitutions by $x' = 0.6f$, and afterwards in continuing them above and below this quantity.

That done, we shall seek in the second table, thus calculated, the consecutive numbers between which each of those of the first is found comprised, and, by the division into proportional parts of the difference between the corresponding values of x or x', we shall then find, to a degree of approximation exact enough for the object in view, as many values of x corresponding to those of u; whence we shall afterwards deduce those of a, by the relation (26)

$$1+a=\frac{1+f(x-m)}{1-u}=\frac{1+x'-m'}{1-u}$$

There will still remain for us to prepare a regular table of the values of x relative to the different successive values of a which we wish to consider; this can be done by known methods of interpolation, or in constructing curves having for horizontal abscissas the values of a thus found, and for vertical ordinates the corresponding values of x.

32. Such in fact is the process which I have followed in calculating the numbers of the following table; but as the curves in question form infinite or hyperbolical branches, having for assymptotes, horizontals situated above the axis of abscissas or of a, at distances equal to the respective limits of x, relative to $u=1$ or a equal to infinity, we can, by this purely geometrical proceeding, obtain, with the desirable approximation, only the first numbers of the regular table just spoken of, and we are obliged to calculate the following numbers by a method of interpolation, which consists in taking for an approximate representation of the hyperbolical branches, an equation of the form

$$x=x_{,}-\frac{k}{g+a}$$

in which $x_{,}$ is that limit of x relative to $u=1$, or $a=\infty$, and which is furnished (30 and 31) by the equation of the 3rd degree:

$$f^2x_{,}^2\left(\frac{3}{2}\frac{p'}{p}-\frac{3}{2}fm+fx_{,}\right)+\tfrac{1}{2}f^3m^3=0.956\frac{f^2}{(1+f^2)}\left[1+f(x_{,}-m)\right]^3;$$

the other two constants, k and g being determined by simultaneous values of x and a, suitably chosen among those which have been found in the first place by means of equation, *(s)* that is to say, among the greatest of them.

It is thus by example in the particular case of earth and masonry of mean densities, and for $m=0$, we find the formula:

$$x=1.243-\frac{1.5443}{1.43+a}$$

which gives to less than $\frac{1}{999}$ the values of x corresponding to values of a, comprised between $a=1$, and even between $a=0.6$ and a equal to infinity. Moreover, we can easily shun this difficulty by adopting the following course, which is very exact, and purely geometrical.

33. After having calculated, as has been explained in the first place, the values of x, relative to $u=0$, $u=0.1$, $u=0.2$, &c., &c., we can construct a curve, having the latter for abscissas and the other for ordinates; there will then remain to be found for each of the values given to a, the corresponding value of x, by means of the relation

$$u=\frac{a-f(x-m)}{a+1},$$

which being linear in x and u, represents a right line, whose intersection with the curve will have for an ordinate the sought value of x. The construction of this right line will be effected very simply, in observing that it passes, whatever may be the particular value of a, by

the point whose co-ordinates are $u=1$, and $x=m-\frac{1}{f}$, a quantity essentially negative, and which therefore is to be carried below the axis of abscissas, or of u; there will only then remain a second point of the line to be constructed, which will be variable only with a, and of which by example the constant ordinate will be taken equal to $m+\frac{1}{f}$, corresponding to an abscis $u=\frac{a-1}{a+1}$, which it will be necessary each time to apply upon the horizontal determined by this same ordinate.

34. That which distinguishes this last method, is that the curves in u and x, which are used, have a form differing very little in general from the arc of a circle, so that for example, it will be sufficient to construct only three points of it corresponding to the values of 0, 0.5, and 1.0 of u, to be able to find immediately, and with a sufficient degree of approximation, the value of x answering to any given value of a. But this remark, which can serve in abridging the calculations for establishing a table, would be of no use in finding a particular value of x, since it would require, for three distinct values of u, the solution of equation *(s')* which, although reduced to the third degree, is not of much easier solution.

This same remark can, moreover, be applied to the foregoing formula (32) of interpolations, relative to the greatest values of x and a, observing that it contains three parameters, $x_,$, k, and g, the general relation of which with the constants f', m, p, and p', does not appear to be easily discovered, even in limiting the degree of approximation to that which practical applications call for—at least our researches on this subject have been fruitless.

We shall soon see that it will be otherwise in the case of small values of a, or of light loads; but it is better, first, to present the result of the numerical calculations which we have made, and which are given in the following table:

General Table

Of Thicknesses (in fractions of the heights) of Vertical Revetments with superincumbent loads of earth, calculated on the hypotheses of rotation, and of their having a stability equivalent to that of the model revetment of Vauban.

Value of $a=\frac{h}{H}$	Values of $x=\frac{e}{H}$, for $p'=p$, $f=0.6$, the berm being		Values of x or $\frac{e}{H}$, for $p'=p$, $f=1.4$, the berm being		Values of x or $\frac{e}{H}$, for $p'=1.5\,p$, $f=1$ the berm being			Values of x or $\frac{e}{H}$ for $p'=\frac{5}{3}p$ $f=0.6$ the berm being		Values of x or $\frac{e}{H}$ for $p'=\frac{5}{3}p$ $f=1.4$ the berm being	
	Zero	equal to 0.2 H	Zero	equal to 0.2 H	Zero	equal to 0.2 H	equal to e.	Zero	equal to 0.2 H	Zero	equal to 0.2 H
0.0	0.452	0.452	0.258	0.258	0.270	0.270	0.270	0.350	0.350	0.198	0.198
0.1	0.498	0.507	0.282	0.290	0.303	0.306	0.303	0.393	0.398	0.222	0.229
0.2	0.548	0.563	0.309	0.326	0.336	0.342	0.326	0.439	0.445	0.249	0.262
0.3	0.604	0.618	0.338	0.361	0.368	0.375	0.343	0.485	0.489	0.274	0.283
0.4	0.665	0.670	0.369	0.394	0.399	0.405	0.357	0.532	0.522	0.303	0.299
0.5	0.726	0.717	0.402	0.423	0.436	0.431	0.368	0.579	0.549	0.332	0.314
0.6	0.778	0.754	0.436	0.450	0.477	0.457	0.377	0.617	0.572	0.360	0.328
0.7	0.824	0.790	0.472	0.476	0.512	0.481	0.385	0.645	0.593	0.387	0.343
0.8	0.867	0.820	0.510	0.501	0.544	0.504	0.391	0.668	0.610	0.413	0.357
0.9	0.903	0.848	0.541	0.524	0.575	0.523	0.398	0.690	0.624	0.437	0.371
1.0	0.930	.873	0.571	0.546	0.605	0.540	0.405	0.707	0.636	0.457	0.384
1.2	0.983	0.916	.632	0.586	0.654	0.574	0.411	0.737	0.655	0.498	0.410
1.4	1.023	0.945	0.684	0.624	0.696	0.602	0.416	0.762	0.672	0.537	0.428
1.6	1.056	0.970	0.73	0.658	0.734	0.622	0.420	0.780	0.685	0.566	0.445
1.8	1.084	0.990	0.772	0.690	0.769	0.640	0.423	0.797	0.697	0.594	0.46
2.0	1.107	1.004	0.812	0.714	0.795	0.655	0.425	0.811	0.705	0.622	0.475
2.5	1.151	1.037	0.902	0.778	0.848	0.690	0.431	0.843	0.722	0.680	0.506
3.0	1.180	1.060	0.981	0.835	0 892	0.717	0.435	0.852	0.731	0.726	0.531
3.5	1.203	1.074	1.047	0.883	0.928	0.738	0.438	0.862	0.737	0.765	0.551
4.0	1.222	1.084	1.105	0.926	0.957	0.755	0.442	0.872	0 742	0.800	0.568
4.5	1.237	1.093	1.158	0.962	0.981	0.768	0.444	0.878	0.747	0.833	0.583
5.0	1.247	1.101	1.206	0.994	1.002	0.779	0.445	0.883	0.751	0.862	0.596
5.5	1.254	1.109	1.250	1.021	1.019	0.788	0.447	0.886	0.756	0.885	0.607
6.0	1.259	1.116	1.290	1.047	1.034	0.796	0.448	0.891	0.759	0.903	0.617
7.0	1.269	1.112	1.357	1.087	1.059	0.811	0.449	0.898	0.764	0.941	0.633
8.0	1.276	1.128	1.415	1.121	1.079	0.822	0.451	0.903	0.768	0.968	0.646
9.0	1.280	1.133	1.465	1.153	1.095	0.830	0.452	0.906	0.770	0.992	0.657
10.0	1.283	1.137	1.508	1.182	1.109	0.839	0.452	0.909	0.771	1.013	0.667
15.0	1.298	1.150	1.662	1.271	1.149	0.864	0.455	0.917	0.777	1.088	0.696
20.0	1.309	1.156	1.757	1.327	1.171	0.878	0.456	0.922	0.780	1.129	0.712
25.0	1.312	1.160	1.821	1.363	1.185	0.887	0.457	0.924	0.782	1.146	0.723
30.0	1.316	1.162	1.866	1.389	1.194	0.894	0.458	0.926	0.783	1.174	0.730
Infin't	1.337	1.175	2.144	1.541	1.243	0.927	0.461	0.934	0.789	1.279	0.769

Consequences and Use of this Table.

35. This table, established upon the same bases as that of No. 20, does not call for any particular explanation, and leads to analogous

consequences relative to the finite and rather small limit of the values of the proportional thicknesses x of the wall; to the variable influence of the width of the berm, &c., &c. It proves, moreover, that the height of the load of earth remaining the same, the thickness of vertical revetments increases, though in a progression a little less rapid than their height, so that in such a wall the stability of the different courses necessarily decreases in descending from the top to the foundation; which, therefore, is the course of least stability even for demi-revetments, a principle which is not evident *a priori*, and which extends to walls with the face in batter, provided that the inclination n to the vertical does not exceed $\frac{1}{3}$.

In fine, the table before us shows, as was advanced in number 23, that the nature of the masonry and earth exercises the greatest influence upon the thicknesses to be adopted in different cases; therefore, we think that when the consideration is in regard to new constructions, in which it is desired at the same time to conciliate stability with a well-understood economy, the final and essential end of all calculations, we should determine with care and by direct experiment, the density of the masonry and the earth, as well as the natural slope of the latter. The earth should be sprinkled, or slightly saturated with water, before ascertaining its density. Moreover, these experiments will be easy, if we weigh the materials entering into any regular part of the masonry, of which the cubical contents could be readily ascertained, and if we also weigh the earth after being well saturated and rammed into a space of known dimensions.

By acting otherwise in doubtful circumstances, where we are in want of examples of constructions properly established, would be trusting to chance, and perhaps uselessly augmenting the expense.

It is also from this consideration that we have not been willing, in accordance with M. Mayniel, whose table is given in a "*Recueil de tables à l'usage des Ingénieurs*," recently published, to designate the masonry and earth by their apparent physical nature, which could easily lead to an error in the density and in the angle of the natural slope of the earth.

Besides this great influence of the given quantities of the question, and the great variations of thickness which correspond to different values of f, p', and p, have not permitted us to give enough columns in the foregoing table, so as to deduce from it, by simple interpolation, the thicknesses of revetments relative to cases or given quantities which are not directly mentioned in it; however, this table will not be the less a great resource in abridging, in each case, the calculation of these very thicknesses, of which, besides, it will immediately make known more or less approximate limits.

36. Supposing, for example, that the question should arise to calculate the proportional thickness, x, of a vertical revetment on the hypothesis of $f = 0.8$ and $p' = 1.2p$: the ratio, a, of the height of the load of the parapet to that of the wall being 2.0, and that m of the width of the berm to this same height, 0.1, we will see, in consulting the horizontal line corresponding to $a = 2$, that this thick-

ness, which would be comprised between 1.107 and 1.004, or equal to $\frac{1}{2}(1.107+1.004)=1.06$ nearly, if we had exactly $p=p'$ and $f=0.6$, and between 0.795 and 0.655, or equal to 0.725 nearly, if we had exactly: $p'=1.5p$ and $f=1$, must be necessarily under 1.06, and above 0.725, which gives 0.9, the arithmetical mean of these numbers for the first approximation. Substituting afterwards this approximate root in equation *(s)* of number 26, and in the expression of u given in terms of x, which, on account of $p'=1.2p$, $f=0.8$, $a=2$, and $m=0.1$, then become

$$u=\tfrac{1}{3}(2.08-0.8x),\quad x^2+\tfrac{4}{9}(x-0.1)^2(x+0.05)=$$

$$=14.337\left[2.28+3u^2+3.125u^3-4.0505(0.64+u^2)^{\frac{3}{2}}\right]$$

we find for the first member of this last equation, 1.08022, and for the second member, 0.55295; which indicates that 0.9 is too great, and that the true root is comprised between 0.9 and .725, so that it can differ but little from their mean 0.813, or more simply 0.8.

This last number, introduced in its turn, in the place of x in the equation, will give respectively: 0.82511 for the first member, and 0.78861 for the second member; which shows that the value, 0.8, is a little too great, but approaching, however, very nearly to the true value. Dividing, now, one-tenth the difference of 0.9 and 0.8 into parts proportional to the absolute differences $1.08022-0.55295=0.52725$, $0.82511-0.78861=0.0365$, of the respective values of the first and second members, obtained in one and the other substitutions, we shall finally obtain $x=0.8-\dfrac{0.03650}{0.56375}0.1=.794$. A degree of approximation sufficient for the particular nature of the question.

Thus, by the aid of the foregoing table, two substitutions alone in equation *(s)* will suffice to obtain, without hesitation or trial, the thickness of any revetment relative to given quantities distinct from those which it contains. In truth, the example which we have chosen, refers to a case where the value of a is found immediately inscribed among those of the first column of this table; but it is readily perceived that these last values corresponding to thicknesses sufficiently exact, it will always be easy, by the rule of proportional parts, to then find those belonging to any particular value adopted for a. It is thus, by example, that if in the place of $a=2$, we should have $a=2.22$, it would have sufficed to substitute for the four thicknesses, 1.107, 1.004, 0.795 and 0.655, which are found inscribed opposite the value $a=2$, the new thicknesses $1.107+\dfrac{0.22}{0.50}0.044=$

1.126, $1.004+\dfrac{0.22}{0.50}0.033=1.019$, &c. &c., since 0.044, 0.033, are the increments given to these numbers, from $a=2$, to $a=2.5$.

Practical formulas for calculating the thickness of vertical revetments on the hypothesis of rotation.

37. The inspection of the table of number 34, shows that the thicknesses due to the greatest loads of earth, follow a very complicated

course with reference to the quantities p, p', f and m; it appears in consequence difficult to subject them to a law or empirical formula approximating sufficiently near the truth; but as has already been remarked at the end of that number, the difficulty does not occur to the same degree in the case of loads which do not sensibly exceed the height of the masonry. This circumstance arises essentially from the fact that all the curves or portions of curves (31 and 32,) which have for abscissas and ordinates the first values of a and of x, furnished previously (27) by the expression *(t)* then afterwards (26) by the equation, *(s)* differ very little from a right line, and can thus be represented approximatively by an analogous equation to that of article 23, and which was verified for the case of earth and masonry of mean densities.

38. Having wished at first to assure ourselves if this very simple formula could be extended to all the cases indicated in the table of number 34, we have found by a discussion relative to the limit of errors which we run the risk of committing in each of these cases:

1°. That if the vertical revetment to which it should be applied was without a berm, we can take to within $\frac{1}{13}$ or $\frac{1}{14}$ nearly,

$$a=0.86 \text{ tang. } \tfrac{1}{2}a.\sqrt{\frac{p}{p'}}\,(1+a),\ e=0.86\,(\sqrt{1+f^2}-f)\sqrt{\frac{p}{p'}}\,(\mathrm{H}+h)$$

from $a=0$ to $a=1$, that is to say, from no load up to one, with a height equal to that of the revetment, for all the hypotheses upon the nature of the earth and masonry, which are embraced in the table.

2°. That if the width of the berm should be comprised between 0 and 0.2 of the height of the wall, we could replace with still less chance of error, the co-efficient, 0.86, of the above formula, by the numbers 0.85, which would make it sensibly coincide with that which was proposed in advance in number 23.

3°. That the greatest errors in either formula correspond to the greatest and smallest values of a, that is to say $a=0$ and $a=1$; so that for all the intermediate values, such as would be wanted in ordinary application, the error, which we risk committing, will generally be very trifling.

39. But the tracing of the curves heretofore described enables us to attain still nearer approximate results, without complicating the formula to an appreciable degree. In endeavoring, in effect, to replace these curves by right lines in such a manner that the greatest relative error of the ordinates may be as small as possible through the whole extent from $a=0$ to $a=1$, we find that these right lines, for the case of $m=0$, or of a revetment without a berm, converge sensibly to the point having for an abscissa $a=-1.126$, and for an ordinate, $x=-0.055$, and meet the axis of x at points which are at distances from the origin equal to 1.0443 times the ordinates belonging to the corresponding intersections of the curves; so that if we should call i these ordinates which, in the case of m and a equal to zero, the one in question, and also having a stability equal to that of the mean revetment of Vauban, are furnished (27) by the expression,

$$i=0.7982 \text{ tang. } \tfrac{1}{2}\,\alpha \sqrt{\frac{p}{p'}}=0.7982\,(\sqrt{1+f^2}-f)\sqrt{\frac{p}{p'}},$$

we shall have

$$x=1.0443\,i+\frac{(1.0443i+.055)}{1.126}\,a$$

$$=0.74 \text{ tang. } \tfrac{1}{2}\,\alpha \sqrt{\frac{p}{p'}}\,(a+1.126)+0.0488\,a,$$

a quantity which will approximate to within $\frac{1}{22}$ nearly of the true value, for all the extent indicated, and for the hypotheses made upon f and $\frac{p}{p'}$ in calculating the table.

40. The berm exercising an appreciable influence in augmenting, as we have seen, (21 and 26,) the thickness a little in the case of small loads, and in diminishing it, on the contrary, in case of great ones, we have sought to introduce its influence approximatively, but only, however, within the extent comprised between $a=0$ and $a=1$, by means of an additive term of the form $k\,m\,(l-a)(a-g)$, which, in fact, possesses the indicated property, and in which k, l and g are numerical co-efficients, determined in such a manner as to render the greatest errors relative to x a minimum.

The discussion and comparison of the results furnished by the above value of x, with the numbers in the columns of the table (34) relative to $m=0.2$, moreover, make us recognise the necessity of introducing the quantities f, or cot α and $p:p'$, as factors, or divisors, of the constants l and k, which leads us to the expression

$$0.56\,m \text{ tang. } \alpha\,(0.6\frac{p}{p'}-a)\,(a-0.25),$$

and consequently to the formula

$$(v)\quad \begin{cases} x=0.74 \text{ tang. } \tfrac{1}{2}\,\alpha \sqrt{\dfrac{p}{p'}}\,(a+1.126)+0.488\,a \\ -0.56\,m \text{ tang. } \alpha\,(a-0.6\dfrac{p}{p'})\,(a-0.25), \end{cases}$$

which represents, to a very satisfactory degree of approximation, the results of the table between the limits $a=0$ and $a=1$, but which it does not answer to extend to cases where the width of the berm exceeds to any degree one-fifth of the height of the revetment; for here again, the quantities m, f, p, and p', have among themselves, and with the variable a, too complicated relations for us to hope that the expression in question may have an analytical form properly adapted to the nature of the question, even under a merely approximate point of view.

41. The same consideration would make us equally hesitate to extend the application of these formulas to values of the co-efficient of stability very different from 1.912, the one which we have adopted, and the square root of which enters implicitly as a factor into the expression for i, which then takes the general form

$$i=0.790 \text{ tang. } \tfrac{1}{2}\,a\sqrt{\frac{\delta p}{1.912p'}} = \text{tang. } \tfrac{1}{2}\,a\sqrt{\frac{\delta}{3}\frac{p}{p'}},$$

which gives in place of the above formula, (*v*),

$$(x)\quad \begin{cases} x=0.927 \text{ tang. } \tfrac{1}{2}\,a\sqrt{\dfrac{\delta}{3}\dfrac{p}{p'}}\,(a+1.126)+0.0488\,a \\ -0.56\,m \text{ tang. } a\,(a-0.6\dfrac{p}{p'})\,(a-0.25.) \end{cases}$$

In general, when the constants, or co-efficients, of a formula of interpolation are functions at the same time of several of the given quantities of the problem, it becomes so much more difficult to obtain an approximate analytical expression for it, that it is necessary to verify it by a multitude of combinations of these given quantities. These considerations should make us renounce the hope of discovering a practical rule, general, and still sufficiently simple for the case of great superincumbent loads; but the regret is less, when we reflect that the case, where the height of the load exceeds that of the masonry, is rarely presented in fortifications; furthermore, according to the calculations of M. Audoy, revetments then run more risk of sliding on the foundations, than of turning over the outer edge of the base of the wall; so that we ought principally to have in view this latter kind of movement in establishing the conditions of equilibrium.

(To be continued.)

Mr. Vignoles' Lectures on Civil Engineering, at the London University College.

[Continued from Page 85.]

SECOND COURSE.—LECTURE I.—RAILWAYS.

Mr. VIGNOLES commenced by saying, that, in pursuance of the order stated in his introductory lecture, he would proceed to investigate the principles upon which railways should be laid out under varying circumstances. In calculating the power (of whatever description it may be) necessary to overcome the resistance of a load to be moved on any railway or road, it may be divided into two parts, viz: that necessary to overcome gravity, and that required to meet friction. The former is, of course, common to, and equal on, all descriptions of roads deviating from the horizontal line, and is in proportion to the sine of the angle of inclination; the latter is regulated by the degree of perfection of the road, and of the vehicles moved upon it, and includes the resistance of all obstacles to the rolling surface, or periphery of the wheel, in addition to the axle friction due to the load or weight placed upon the carriage. It has been assumed, from experiments and observation, that the average friction upon a railway is 9 lbs. per ton, and that this continues the same at all velocities; but there is reason to believe that the latter part of the assumption must be much qualified. The gravity due to the inclination of the plane being added to, or substracted from, the friction, as the

plane rises or falls, the sum, or difference, will give the total amount of power necessary to overcome the resistance of the load. The power necessary to overcome the gravity being expressed by the proportion which the rise of the plane bears to the weight to be raised (say, for example, a ton,) is found by dividing 2240, the number of pounds in a ton, by the denominator of the fraction which expresses the inclination of the plane; thus, on a plane rising one foot vertically in a horizontal distance of 1000 feet, the fractional expression is $\frac{1}{1000}$, and the power (retarding or aiding the load,) will be the thousandth part of a ton, or 2¼ lbs. It is evident that, as we arrive at steeper inclinations, this power will at length become equal to that required to overcome the friction; thus, on an inclination of $\frac{1}{240}$, it will be $\frac{2240}{240} = 9$ lbs. per ton, and this being subtracted from the friction, on a railway which is commonly taken at that same amount of 9 lbs. per ton, it results that no power is required to move a load down such an inclination, or wherever the gravity and friction are equal and balance each other. The angle that such an inclination makes is called the angle of repose, but will, of course, vary with the friction due to various descriptions of roads and vehicles. On steeper inclines than such, not only is no power wanted, but there is a gravitating power due to the descent of the plane, and so strongly does this act in steep inclinations, that it is necessary to put on the brake, to retard the velocity which it occasions. It is found, however, when a train is allowed to descend a steep plane without retardation, that, owing to the resistance of the air, it will, after acquiring a certain velocity, cease to be further accelerated; many theoretical writers have fallen into error, by supposing it dangerous to allow trains to descend inclinations steeper than the angle of repose without applying the brake. On railways where there are inclined planes of $\frac{1}{100}$, for several miles together, the trains often commence the descent at the rate of forty miles an hour, and the speed, instead of being accelerated, has been quickly reduced to little more than the thirty miles an hour, or to such uniform velocity that a railway train will acquire on that inclination, varying a little with the weight of carriages, or the length of the train; such being the case, it is evident that lines of railway for locomotive power, can be safely laid out with inclinations of 1 in 100, and even steeper.

It is of the utmost importance, in laying out a line, to consider the power which is proposed to be employed, and the mode of obtaining it; thus, if it be intended to lay out a horse railway, to carry coal from a colliery to a shipping place, the line should be made always to descend, and so regulated, that the number of full wagons that may be sent down be that number which may be taken back empty. But horse-power being extremely limited, recourse is had to steam, and the locomotive steam engine has been applied to railway traveling, as being better suited to the purpose than animal power. The power of the locomotive engine may be defined, not so much by horse power, or cylinder power, as by boiler power, or capability of rapidly supplying steam to the cylinders, and still more by adhesive power, or the weight insistent on the driving wheels, so as to have

purchase, as it were, to drag the load after it, for the wheels will slide, more or less, and, under some circumstances, will merely turn round on the rails, without progressing. Many lines appear to have been laid out under the impression that the locomotive engines would always have to carry a *maximum* load, and, in accordance with this principle, and to enable them to do so, it was some short time since laid down as an axiom, that no inclinations should exceed $\frac{1}{330}$, and that gradients should be constantly uniform through the whole length of a line. Experience has shown, however, that the practical cost of conveyance of ordinary trains over lines greatly varying in their gradients, does not materially differ, the wear, and tear, and fuel, seldom being increased so much as 10 per cent., and other expenses and contingencies being the same, whatever the gradient of the railway, the difference on the whole expense of working and maintenance becomes very small indeed. In laying out a line, then, the traffic must be considered quite as much in the distribution of it as in the totality; for it is evident that, to accommodate the public, the trains ought to go often, and will, therefore, generally be light; and when we consider the great economy in construction, and the little additional expense incurred in the after working, we may conclude that railways may be advantageously laid out with much steeper inclinations than they have in general hitherto been, particularly in the remoter districts, where the railway system has not yet been extended. A powerful engine will draw an immense load on a level, whereas it often has not more than twenty tons to draw—consequently, gravity ceases to become an object; and even should the traffic increase in course of time, it will be better to send frequent and light trains, than in the original construction, to incur heavy cost to graduate the road for heavy trains, which are seldom to be carried. This principle must, of course, be confined within certain limits; thus, lines may be laid out with better gradients, where the traffic is very great, and will justify the expense and inconveniences which might result from an engine having always to go up a steep ascent. Railways in England have cost, on the average, £30,000 per mile, and the first cost of locomotive power does not amount to one-fifteenth of that sum. The interest on the capital is, therefore, very great, while that on the power is small, as is also, comparatively speaking, the daily cost of transit due to the power only. If these proportions were different, the latter being increased, while the larger amount (the interest on the cost of the works) were diminished, the capital sunk in railways might have been reduced fully one-half, with equal satisfaction and benefit to the public, for whose use they were designed, and with greater profit to the shareholders.

LECTURE II. RAILWAYS—LOCOMOTIVE POWER.

In the last lecture it had been stated that the adhesive power of the locomotive engine depended upon the weight borne upon the driving-wheels. The greatest amount of adhesion of iron upon iron, according to the experiments of the eminent engineer, Mr. George Rennie, as published in the *Philosophical Transactions*, appears to

be about one-sixth or one-seventh of the weight of the insistent load. In the locomotive engine, where the bearing of the wheels is upon smooth surfaces, the adhesion will, of course, be less; and in weather when rime or mist congeals upon the rails, it is very small indeed, sometimes none at all. But in ordinary states of the rails, and of the atmosphere, one-fifteenth may be taken as an average. The vicissitudes to which this power is subject, will often account for the varying rates of railway traveling, and it is only when the resistance of the load is less than the smallest amount of adhesive power which the state of the weather or the rails will admit, that the time of transit of a train over any given distance can be insured. Now, the usual weight bearing upon the driving-wheels of an ordinary locomotive for passenger traffic, is about seven tons, or 15,680 lbs.; one fifteenth of this will be 1042 lbs., or, in round numbers, say 1000 lbs., for the average available adhesive power of such an engine for moving a load, and on the amount of this alone will depend the weight which the locomotive engine can draw after it. The other principal element which must be taken into account in the locomotive engine—viz. the speed—will depend mainly upon the power of the boiler to generate steam with sufficient rapidity. A boiler may have quite sufficient power to move (at a velocity of three miles an hour) a load of which 1000 lbs. shall be the representative, but it must be of a far superior description, and far higher powers, to move the same load at a velocity of thirty miles an hour; and this subject does not appear to have been sufficiently considered, though it is of such paramount importance thoroughly to understand the nature of the moving power to be used, before going into the subject of the gradients, or the principles of laying out the line. The amount of the load, then, which the engine can draw, will depend chiefly on the adhesion, and the velocity will depend on the boiler where the steam is generated, the cylinders being proportioned to each of these two other regulating powers. And not only must the steam be generated to a given pressure to produce that power, but with sufficient rapidity to continue it; and in keeping up a high velocity, it must be, as it were, rammed into the cylinders, so as to produce the greatest possible effect in the least possible time, and this is the reason why high velocities are so very expensive, as the same effect might be produced by one-fourth the quantity of steam, if sufficient time were given to expand it. But there is yet another circumstance that modifies the amount of adhesion—viz. the inclination of the road. It is manifest that, if the road were vertical, the engine could have no adhesion upon the rails; and, therefore, between the perpendicular and horizontal lines, the power must undergo many degrees of variation, quite independent of the atmospheric causes already mentioned. We have no experiments to determine the ratio of that variation, but, reasoning from analogy, it may be assumed to be as the sine of the angle of inclination, or in the same proportion as the resistance arising from gravity, so that practically the diminished amount of adhesion, on any inclined plane, might be found by deducting the resistance of gravity on that plane from the constant of 1000 given above; thus, on an inclination of 1

in 100, the gravity of the engine per ton (or 2240 lbs.) will be $\frac{2240}{100} = 22.4$ lbs., and that for seven tons will be $22.4 + 7 = 157$ lbs., which subtracted from 1000, will give 843=the diminished amount of adhesion, which will be the limit of the power of the engine on that incline, as regards the load, no matter how great the boiler or cylinder power may be. And to find the load which this power will draw, we must take the sum of the resistances arising from gravity and friction for one ton, and the adhesive power divided by this sum will be the amount sought in tons; on an inclined plane of 1 in 100, the calculation will be found thus:—Friction 9 lbs. per ton, *plus* gravity as before, 22.4=31.4 lbs., and adhesive power 843, divided by 31.4=26.7 tons, which is only one-fourth of what might be drawn on a horizontal line. Hence the advantage of heavier engines, which are daily coming into use, as also the propriety of coupling the wheels of engines for drawing heavier loads up steep inclines, and by this means the whole insistent weight of the engine is rendered effective by adhesion, and the load the engine can draw after it proportionally increased. In calculating the amount of resistance of a load upon a railway, the friction had been assumed to be 9 lbs. per ton, rather in deference to general opinion than otherwise; it was probably much higher. It is considered that the friction of the engine and engine gear is 16 lbs. to the ton, but that of the lighter carriages less; however, if this number (9 lbs.) should be proved incorrect by future experiments, the principle of the calculation will not be altered, and it will only be necessary to substitute the true number instead of 9. The same may be said with regard to the adhesion; it will only be necessary to substitute for 1000 whatever number shall be found on closer investigation to be nearer the truth.

The power generated in the boiler, and applied in the cylinders, now remains to be brought under consideration. This may be stated to be the capability of the boiler to supply steam of high pressure, to enable the piston to perform a given number of strokes per minute, which accordingly will be one of the essential elements in computing the power of the engine; and therefore it is that we are always unwilling to define it by any number of horses' power, since it is clear that the engine which, moving at the rate of 15 miles an hour, would be called a 20-horse engine, would be styled a 40-horse engine when moving at the rate of 30 miles an hour, all other circumstances remaining the same. But it does not follow that, because the number of strokes per minute be increased, that the power available for locomotion be increased also, and in this consists the essential difference between locomotive and stationary engines, for in the former there are circumstances, as before shown, which circumscribe that power, over which the boiler has no control; and, as regards the locomotive engine, a third point must be taken into consideration. It is a well-known theory, that, if a metallic substance be in contact on one side with water, and that heat be applied to the other, that once the body becomes thoroughly warmed, the caloric will be taken up by the water with as much rapidity as it can be supplied to the metal. Now, in the locomotive engine, there is an immense area of heating surface

in contact with the water in the boiler, in consequence of the numerous tubes which pass through it from the fire-box to the chimney, and it is on this principle that what is called the steam draft has been introduced, by which means the caloric is rapidly drawn from the fire through these tubes, and as rapidly absorbed by the water with which they are in contact, for the production of steam. It is evident that, in proportion to the rapidity with which the piston moves, and with which the waste steam is injected into the chimney, will the heat be absorbed by the water from the tubes and steam generated, the effect of which is, that the faster the engine goes, the quicker it generates the steam; and this forms another great beauty and peculiarity in the locomotive engine. The principles of calculating the moving power being thus explained, the way has been sufficiently cleared for entering on the subject of the laying out of railways.

Lecture III.—After recapitulating a few of the leading points which were stated in the last lecture, the Professor called particular attention to the formula whereon he had based the calculations into which he had then entered, and he now exhibited tables and diagrams in further illustration. The adhesive power of 1000 lbs. was assumed as the average of what a locomotive engine will have in all states of the weather, and of the rails; but if the wheels be coupled, or the insistent weight otherwise increased or diminished, the adhesive power (on which depends the load) will be altered in the same proportion, subject also to variation from the state of the weather and the road, and undergoing the stated diminutions from the effects of gravity on all planes which depart from a horizontal line, the velocity of the train depending on the evaporating power of the boiler. But in the stationary system the engine winds (upon a roller, or over a sheave or wheel) a rope supported by pullies, placed at regular distances along the road, and to which rope the train is attached. Mr. Vignoles stated that the student may refer with confidence for every information on this subject, to Mr. Wood's *Treatise on Railways*, and commented on the extracts he made from that work.

Atmospheric Railway.—There is also another mode of applying the stationary engine to the purposes of locomotion, by producing through an air pump a partial vacuum in a pipe, thus making atmospheric pressure the moving power; and it may be interesting to state, that the scientific men who were appointed by the railway department of the Board of Trade to inquire into the system of the Atmospheric Railway, had fully recognised that principle, and concurred in considering that the experiment contemplated upon the Dublin and Kingstown Railway extension, and recommended by the directors to the proprietors, as applicable for illustrating the principle on a large scale. On the atmospheric railway the diameter of the pipe or tube regulates the load, but the velocity depends almost entirely upon the diameter of the air pump that exhausts the pipe, the rule being that the area of the air pump must be made as many times greater than the area of the pipe, as the velocity of the train is to exceed that of the piston of the air pump. Thus, if the piston of the air pump be supposed to move at a rate of three miles an hour, and it be required

to move a train at a velocity of thirty miles an hour, the area of the air pump must be made ten times the area of the pipe; the diameter will, of course, be deducted from that area. Now, it appears that the most economical pressure in the pipe (which is what engineers must chiefly look to,) is about 7 lbs. to the square inch, or rather less than half a vacuum; therefore, this may be taken as the constant of the atmospheric pressure; and if we multiply this constant by the area of the traveling piston in inches, we shall obtain the effective pressure upon that piston, which, as it regulates the load, may be said to correspond to the adhesive power in the locomotive engine, but which, unlike that power in the locomotive, will be undiminished on inclined planes. Again, if we divide this power by the friction (which was before taken at 9 lbs. to the ton,) we shall obtain the number of tons which the piston, acted on by the atmospheric pressure, is capable of propelling. Thus, supposing we have a pipe of 14 inches diameter, if we multiply the area of this pipe by 7 lbs., we shall find the effective pressure equal to 1078 lbs., which, divided by the friction, 9 lbs., will give about 120 tons—the weight which can be propelled by means of a pipe of that diameter; and if the piston of the air pump move at the rate of three miles an hour, and its area equal to seven times that of the pipe, the load will be moved with a velocity of twenty-one miles an hour, and it may be demonstrated that, on ascending and descending planes, the speed, although increased or diminished at first, will soon become uniform. Of course, upon the diameter of the air pump will depend the power of the engine which is to work it. The calculations in this case will be similar to those for an engine required to work ropes—in the one case it being required to find what is wanted to overcome the resistance and friction from ropes, pullies, &c., and in the latter to find the power to work the air pump, and exhaust the air from the tube at any required velocity.

Inclined Planes.—The Professor then recurred to the effect of trains descending inclined planes. Mr. Navier (in his work, translated by Mr. M'Neill, which he mentioned as a text book on the comparison of different lines of railway,) differed somewhat from the propositions he had laid down; it was therein stated, and Professor Barlow concurred in the statement, that an engine and train did not gain any advantage in descending planes steeper than a certain inclination which they have put as the angle of repose. Now, in practice, Mr. Vignoles did not find it so, but, on the contrary, daily experience proved that, as far as inclinations of sixty feet in a mile, the trains may, under almost all circumstances, have the full benefit of gravity in the descent. Professor Barlow has laid down, in several important works, which, from their high standing, will have a material influence upon the public mind, that though additional power be required to surmount steep inclinations, yet, so far from gaining a corresponding advantage in the descent, there will result rather an injurious effect from the necessity of applying the brake. Now, it has been already mentioned, and experiments have been repeatedly made by Mr. Wood, Dr. Lardner, and others, showing that, when

engines descend long inclined planes, such as those on the Croydon Railway, the application of the brake is seldom necessary, the speed that would be due to the accelerating force of gravity, being reduced by the resistance of the atmosphere, until it settles down to a uniform and safe velocity. It is evident, therefore, that there is a great deal yet to learn on this subject, when we find authority and practice differing so materially. Mr. Vignoles observed, in conclusion, that, as the laying out of the lines of railway ought to be strictly regulated by the power to be used for locomotion, as well as of the load of each train, and the nature of the traffic, it becomes interesting to consider these principles in respect of the extension of the railway system in this and other countries; for, looking at the enormous outlay hitherto incurred, lines through remote districts would not be undertaken, unless the first cost of railways, and the annual expense of working and maintaining them, were reduced to a *minimum*.

To be continued.

Description of a Bridge of Béton, (Concrete,) constructed at Grisoles, in the Department of Tarn-et-Garonne, in France.† By* M. Lebrun, *Architect, of Montauban.*

Translated for the Journal of the Franklin Institute, from the "Bulletin de la Societé d'Encouragement pour l'Industrie National," for July, 1842. By Ellwood Morris, Civil Engineer.

Living in a region where suitable building stone is scarce and expensive, and where brick masonry alone is used, M. Lebrun, guided by the fine works of M. Vicat, on hydraulic limes, conceived the idea

* The French *béton* is nearly identical with the English *concrete*, the main difference being in the manipulation; thus *béton* is composed of lime, sand, and small pebbles, or broken stone, *taken separately*, and successively mixed together, the pebbles being added last; while *concrete* is usually formed of lime, mixed directly with gravel, *containing naturally* about the due proportion of *pebbles and sand;* proper quantities of water being used, and the factitious stone resulting, in both cases, being in effect the same.—Tr.

† Béton, or concrete, has before been used in retaining walls and other constructions, and, as is stated by Gen. Pasley, of H. B. M. corps of Engineers, (in his admirable Treatise on Calcareous Cements,) it was also applied experimentally to build a military casemate near Woolwich, of which the arch had 18 feet span, 5 feet rise, and 6 feet depth at the crown, and which, when subjected to the direct fire of 24 pounder guns, as well as the vertical plunge of 13 inch shells, loaded to weigh 200 lbs. each, resisted both with success, and, contrary to expectation, was less injured by the latter, than by the former.

General Treussart, of the French army, after mentioning the successful construction of several concrete vaults, recommended this material for aqueduct bridges, and for the revetments of fortresses, in certain situations.

Nevertheless, the bridge above described is amongst the first, *if not the very first*, construction of that nature which has been successfully executed for ordinary use, and its success will suggest at once to the mind of the American engineer, many situations, in the southern section of the Union, at least, where concrete may thus be used with great propriety and economy; indeed, its comparative cheapness, in some cases, would fully justify a fair trial of it, even in the northern United States, though the severity of the winters, there, would seem to render its success in that region more problematical.

We must, however, observe, that the failure of the concrete wharf walls, at Woolwich and Chatham, in consequence of tidal exposure, and the necessary protection of the concrete sea wall at Brighton, with woodwork, to shield it from the action of water in mass, (as mentioned by Gen. Pasley,) points out the necessity of confining the application of *concrete* to constructions, within reasonable and proper limits.—Tr.

of substituting for this masonry the *béton*, which the Romans used with so much advantage.

In consequence, he submitted, in 1839, to the Minister of Public Works, the project of a bridge entirely of *béton*, which he offered to construct on the lateral canal of Garonne, to be traversed by many of the royal and departmental routes. This offer having been accepted, under certain conditions, M. Lebrun commenced his work in June, 1840.

I.—*Selection and Preparation of the Materials.*

The *lime* was of the hydraulic quality, burnt in perpetual kilns, by pit coal. The *sand* was clear of all earthy particles, of fine grain, and pretty uniform. The *gravel stones*, of the size of a hen's egg, came from the river Garonne. The lime was slaked alternately in two basins, joined together. For this purpose, we poured at first, in one of the basins, a quantity of water proportioned to that of the lime which we wished to slake; we then put in sufficient quicklime for the water to cover it; then we left the lime to slake freely without disturbance, except by taking care to prick it, from time to time, with a stick, to introduce the water into those parts of the basin where the dissolved lime was dry. When the fermentation had ceased, we stirred up the lime in every direction with an iron hoe, in order to mix the paste, and render it homogeneous; we left it then in this state, not to be used for twelve hours after slaking.

The proportions observed by M. Lebrun for concretes (bétons) destined for the construction either of walls or arches, were, in every ten parts, composed of two parts of lime in paste, three parts of sand, and five parts of gravel stones, or pebbles.

For making the mortars, we placed, on a paved surface, two measures of the slaked lime, which, after having been well beaten with pestles of cast iron, softened again by yielding up a part of the water with which it was charged; then we placed beside it three measures of sand, which we mixed, little by little, with the lime, always having the aid of the pestles, and stirring the whole with the shovel and hoe, in order that all the parts of the sand should be well incorporated, observing not to put any water into the mortars, but, if the sand was too dry, we moistened it, a few moments before mixing. As soon as the mortars were sufficiently manipulated, we added five measures of gravel stones; the whole was then long and forcibly mixed and pounded, until each part of the gravel was sufficiently enveloped by mortar; then the *bétons* were taken in quantity, to wait for the moment of being used. We took care to make only what we could employ in a day's work, without which precaution it would have lost its cohesion.

II.—*Construction of the Abutments.*

The 15th of June, 1840, the excavation of the foundations of the two abutments being done, we commenced laying the *bétons*, taking care, each time that a layer, or course, was finished, to cover it up

immediately with wet mats of straw, to prevent a too rapid drying by the heat of the sun. By means of this precaution, the new course connected itself more intimately with the one below. We continued the masonry all of *béton*, (the backing of the arch and abutments keeping pace,) until reaching the height fixed. The exterior faces of the abutments, (not next the earth,) and of the walls, were formed by some planks strongly fixed, against which the *béton* rested. These planks were removed, two or three days after, and the faces of *béton* remained exposed, and were very well preserved. At the height of the springing of the arch, we laid five courses of bricks plumb on the faces of the abutments, to serve as perpendicular faces for the centre to fit up against, and enable it to detach itself easily.

III.—*Construction of the Centre.*

Fifteen days after the laying of the last *bétons*, we commenced the construction of the centre, composed of many courses of bricks, laid flat, in succession, (from the spring towards the crown,) following the curve of the arch at the intrados, built partly with plaster, and partly with cement, or hydraulic mortar, and supported at the springing by projecting masonry, or by a timber for that purpose. The centre was formed of four courses of bricks, (in thickness, or depth, say nine inches;) the three lower were laid with plaster, and the upper course with cement, to shelter the plaster from the dampness of the *béton*. The upper bricks of the centre were covered by a bed of mortar of clay, in order to model perfectly the intrados of the arch, and to hinder the *béton* from forming one body with the bricks.

The construction of the centre being finished on the 17th of August, we established, three days after, the masonry of the two heads of the arch of brick, (in lieu of ring stone,) which were completed on the 26th of the same month.

IV.—*Construction of the Arch.*

Immediately after the construction of the two heads, we wrought them into the general mass of *béton*, forming the arch; this operation was finished on the 5th of September, with the exception of the backing up, which was accomplished, on both sides, the 11th of the same month. The *bétons* of the arch were composed in the same manner as those of the abutments, and manipulated by the same process; but we added to it $2\frac{1}{10}$ cubic feet of *cement* for every $35\frac{1}{4}$ cubic feet, or $\frac{1}{17}$th, of the mass, to augment the strength of the mortars of the body of the arch. This construction was made without following any regular order, and the *bétons* were cast in masses, upon the centre, to the thickness of two feet, which formed the first general bed, or layer, on the development of the arch. This first bed being finished, we formed the second in order to reach the thickness of three feet at the key, the spandrel backing, and the abutments being leveled up. A coping of hydraulic mortar was then placed over the whole extent of the arch, and covered immediately with a layer of clay, strongly beaten.

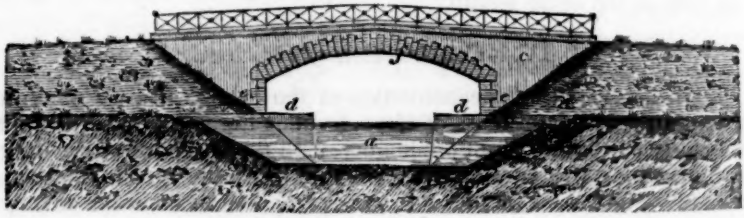
V.—*Decentrement.*

All was left in this state until the 25th of January, 1841; we then proceeded to the operation of the decentrement of the arch. The 28th of January, the centre of bricks was taken away, and the intrados of the arch appeared very even in all its parts. After three months, it manifested not the smallest settlement in its masonry, and, since then, the bridge has stood through the summer, without incurring the least degradation capable of affecting its solidity. This bridge has a clear opening of 39⅓ feet between the abutments; the middle is placed in the axis of the canal, which has two towing paths; its breadth is 19⅔ feet between the heads, or faces, of the rings; and the arch is formed of a segment of a circle of 39⅓ feet chord, and 5¼ feet rise, or versed sine.

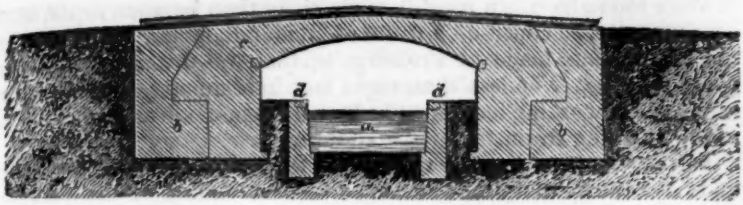
The entire mass of the abutments is of *béton*, except the four angles on the sides of the towing paths, which are of large stone, rounded on the arris, on account of the rubbing of the towing lines. The arch is also of *béton*, as are the faces of the tympans, or spandrels, and the intrados, with the exception of the arrises of the soffit, or rings of the heads, which are of brick masonry.

M. Lebrun has joined to his memoir, along with a plan of the bridge of Grisoles, many certificates, from the mayor of this commune, and from the engineer of the lateral canal of the Garonne, proving the complete success of the works, and the solidity of the construction, which has endured the proof of the passage of loaded carriages, the numerous influences of heat, and some very severe frosts, without having suffered the least degradation.

VI.—*Explanation of the Figures.*



a, canal.
b, abutment of *béton*.
c, mass of arch, also of *béton*.
d d, towing paths.
e, angles of bridge upon the tow-paths, built of large stone, with the angles rounded.
f, arrises of the soffit, or bands of brick at each head of the arch, instead of the usual ring-stone.



On the Advantage of Wire Rope over Hempen ones. Extracts from the Mining Journals of Freiberg. Arranged for the Journal of the Franklin Institute, by THEO. F. MOSS, *Mining Engineer, Philadelphia.*

Since the introduction of the wire ropes in the mines of Saxony, experience has proved them to be more advantageous than hempen ropes, both in cheapness and in durability, which has warranted their general introduction into all the mines of Saxony.

The price of hempen rope of 288 threads, is, per lachter, (equal to two French metres, or 78⅝ English inches,) 1 thaler 20 groschen, about $1.27½ of our money. An iron wire rope, used in the place of the above hempen rope, costs, per lachter, 15 groschen 3 pfennings, or about 46 cents; therefore, the price of the hempen rope of 288 threads is, to the price of the wire rope which replaces it, as 1 is to 0.3483; consequently, the wire rope is 65.17 per cent. cheaper than the hempen rope.

The price of a hempen rope of 336 threads, the largest used in the mines, is 2 thalers per lachter, or $1.38; this is replaced by wire rope of 16 wires, which costs 47 cents per lachter, or in the proportion of 1 to 0.3405.

Hence, the wire ropes are two-thirds cheaper than the hempen ropes which they replace, and, under many circumstances, of greater durability, particularly in moist situations, or where the rope remains for a long time coiled on the drum, when it decays from mildew.

Besides these advantages, the wire ropes are one-third the weight of the hempen rope which they replace.

Wire rope of 12 wires weighs, per lachter, (equal to 2 French metres, or 78⅝ English inches,) 3.4309 pounds; hempen rope, of 288 threads, weighs 9.62 pounds, or as 0.3536 is to 1.

The wire used is 3.3 millimetres in diameter, equal .039 inches, and the strength of the wire ropes is in proportion to the number of wires. The wear and tear of wire ropes is less rapid than by hempen ropes; consequently, the hempen ropes, to have an equal durability with wire ropes, must, at the outset, be much stronger.

The maximum strength, or breaking strain, of hempen ropes of 288 threads, is, expressed in pounds, equal to 19,800 pounds; whereas the breaking strain of the wire rope of 12 wires, used in the place of the above hempen rope, is, when new, 11,200 pounds.

Wire ropes, having a much less elasticity than hempen ropes, must, consequently, be coiled on a drum of greater diameter. The result of the experiments made at Freiberg, is, that the drum for iron wire ropes must never be less than eight feet in diameter, and the maximum of the working load must be between one-sixth and one-seventh of the breaking strain.

Wire ropes have been in use since 1834 in the mines of the Harz, and have been lately introduced at the coal mines of the northern counties in England, and on most of the railroads where stationary engines are used.

Messrs. R. S. Newell & Co., Patent Wire Rope Works, Gateshead, county of Durham, Eng., publish the following comparative card:

Comparative Table of the size, weight and cost of Hemp and Wire Ropes.						Newell & Co.'s scale price of Wire Rope.			
Hemp Ropes.			Wire Ropes.			lbs. weight per fathom.	Breaking strain.	Working load.	Price per cwt.
Circumfer'e in inches.	lbs. weight per fathom.	Cost per fathom.	Circumfer'e in inches.	lbs. weight per fathom.	Cost per fathom.	lbs.	ton. cwt.	ton. cwt.	s. d.
		s. d.			s. d.	2	3.12	0.12	80 a 75
						3	5.8	0.18	
						4	7.4	1.4	75 a 70
						5	9.0	1.10	
3	2¼	0.10	1¼	1¼	0.11¼	6	10.16	1.16	
4	4	1.6	1¾	2¼	1.7	7	12.12	2.2	
5	6¼	2.4	2⅛	3½	2.2	8	14.8	2.8	70 a 67 6
6	9	3.4½	2½	5	3.2½	9	16.4	2.14	
7	12¼	4.7	2⅞	6¾	4.2½	11	19.16	3.6	
8	16	6.0	3⅜	9	5.5¼	13	23.8	3.18	67 6 a 65
10	25	9 4½	4⅛	14	7.10½	15	27.0	4.10	
12	36	13.6	4½	20	10.5	17	30.12	5.2	65 a 62 6

Facts and Observations on Four and Six Wheel Engines.

By JOHN HERAPATH, ESQ.

[Continued from Page 89.]

Eastern Counties Railway.

The Eastern Counties Railway is the longest projected line in England, being 126½ miles from its commencement in London to its terminus at Yarmouth. Its original projection was in 1834, but owing to some political affair at Ipswich, it was abandoned, and renewed again in the year 1835.

A very remarkable feature of this line is its not having a single tunnel throughout its entire length, 126½ miles. Such an instance, perhaps, is unparalleled in British railways.

At present there are only 17½ miles completed, namely, from London to Brentwood, but in the fall the remaining 33½ to Colchester it is fully calculated on will be opened to the public.

The rails are 75 lbs. rails, laid upon cross sleepers, which we un-

derstand, in cuttings are 5 feet apart, but on embankments about 3 feet 6 inches.

One of the heaviest works is the Brentwood Hill cutting through clay, which is 1¾ mile long, and averages about 40 feet deep. Here is an incline of 2½ miles long, at 52¼ feet per mile.

A very troublesome work also is what is called the Gubbins embankment, which is 2½ miles long, and 30 feet high, on the London side of the Gubbins cutting. This embankment is composed of a soapy clay of a very treacherous description, and has given great annoyance to the Company. They are now piling it at the sides, and carrying immense cross timbers right through the embankment, from pile to pile, on which longitudinal bearings are laid for the rails to rest on. It is contemplated by this means to get rid of, in future, all the annoyance of any sinking in the material, and preserve a good sound road.

We perceive, at the London end of the line, they are turning the arches into storehouses, carriage offices, &c., which must necessarily save the Company a considerable sum in buildings or rental. As far as I saw, the old arches were quite dry, and well adapted for the purposes to which they are applied. Here I had an opportunity of inspecting the manner in which they kept their store accounts, which was both simple and effective.

As this viaduct runs through a very populous neighbourhood, it is not improbable but that the Company may eventually turn the arches to account, in the way of letting them either as storehouses, or for other purposes, and of course realise, if all let, a good round rental per annum.

The station at this end of the line is large, and may be made very commodious for the two Companies—the Eastern Counties, and the Northern and Eastern; but at present it is unfinished. It is 260 feet long, and 130 feet wide. The roof, which is made of corrugated iron, is divided into three compartments, and has an extremely light and airy appearance, so much so, that we should be inclined to think with the first high wind it would be blown away. However, it has now stood one or two winters, and has put beyond a doubt the question of its stability.

One of the peculiarities of this line is the signals for the stopping and regulation of the trains. This ingenious system is the invention of Mr. Hall, the present manager. By this code of signals a man is saved at every station. For the policeman who has the care of the signals, which are 100 yards from every station each way, being able to let down or raise the signal without leaving the station, can lower it the moment a train passes it, and be ready to attend to the passengers before the train reaches the station. The signal consists of four compartments, leaves, or panels, each being the 16th part of an entire circle. These panels are let down by a policeman immediately on a train passing, with the colored spaces or sides towards the parts from which the train has come, and it is allowed to remain so five minutes after the train has passed, when the lower panel begins to wind up slowly behind the next above it, either by means of clock-

work, or windlass and pullies. At 7½ minutes the two lower ones are pulled up behind the second, and at the end of ten minutes, the second, third, and fourth are pulled up behind the first, and the whole wound up at the end of 15 minutes. The panels are painted, yellow the first; green the second; and red the third and fourth. By the manner of managing these signals, the time at which a previous train has passed is known. Thus, if all the panels are down, a train cannot have been gone five minutes; if only three are exhibited, it cannot have passed 7½ minues; if only two, ten minutes; and if they are all drawn up into the box, it must have passed at least, 12½ minutes before. A man at one point can work easily three of these signals, at 150, or 200 yards from him on either side. The colors are also made to signify the speed at which the trains are to travel. For instance, if any part of the two red panels is visible, no train is allowed to pass. If the yellow and green, their speed must not exceed 15 miles an hour, until they arrive at a post with green and white stripes a mile onward. If only the yellow is visible, the rate must be reduced to 24 miles an hour, and if they are all boxed up, the line is clear, and they may go at their usual speed.

This is the completest code of signals I have yet seen.

My first trip down the Eastern Counties line was on Saturday, Jan. 22nd, with Mr. Hall, the manager. We went down as far as Stratford on No. 11, and returned on No. 17, engines. Both these engines were Bury's make, and four-wheel engines. No. 11 had been out for some months, hard at work, and, notwithstanding, had very little motion. No. 17 had only been out two journies, but we did not go fast enough to determine what her motions were.

April 4th I went again over the line, as far as Brentwood and back, on No. 13 engine, which had been about 9 or 10 months out. Her pressure appeared to be 60 lbs. to the inch. She had 6 feet wheels, and had no longitudinal motion when going fast. I fancied, however, she was rather loose in the brasses, though very steady at high speeds. She had a little side wriggle behind, and was rough on the platform. I went afterwards on No. 14 engine, 5½ feet wheels, 18 inch stroke, and 13 inch cylinder. This engine had no such side wriggle as the last, was smoother in her motions except on rough ground, which was owing to her coming down on her stays with every jerk, her springs not being sufficiently strong, or not having play enough. Neither of these engines had any sensible longitudinal motion, but in this respect ran very sweetly. I, however, perceived a tendency to roll and pitch in No. 14.

Except that No. 13 had 6 feet wheels, and No. 14 only 5½, these engines appeared to be counterparts of eath other.

On No. 13 we tried the experiment of suddenly cutting off the steam at high velocities, but could perceive no effect that it had upon the engine.

April 11th I went upon another engine, No. 15, her wheels, stroke and cylinder were the same as No. 14. She had no longitudinal motion, but was exceedingly sweet in her movements. I was informed she had been out 7 months, but within the last two days had had her

brasses lined, which may partly account for her tightness and very easy motions. They were obliged to keep the water very low in this engine, in consequence of her priming so. I was informed that her ports were very large, to which the engineman attributed much of her superiority in motion.

I was glad to observe in all their engines that they had lately had sheet iron put round the platform, and that over the wheels there were brass dashing plates. The whole appearance of the Eastern Counties engines is that of extreme neatness and cleanness. They work two days and are in one, which gives the men an opportunity of keeping them clean, and of attending to any repairs that may be wanting.

On these Eastern Counties engines I noticed the same activity and facility in starting and taking off a load, which I had remarked in other four-wheel engines. Whatever may be the cause, there certainly does appear to exist *a command over the loads*, if I may so call it, in four-wheel engines, which I have never observed in the six-wheel. So striking is this circumstance, that one unacquainted with the loads would imagine that four-wheel engines seldom or ever had heavy loads after them, and that they were always reserved for six-wheel engines.

The number of engines this company have is 17, of which two are with coupled wheels, and 4 ballast engines. They have 8 more building, in preparation for the intended opening, on October 1st., of the new part from Brentwood to Colchester. The complete stock for working the entire line of 52 miles long will be 35; all are four-wheel engines, have inside bearings, and are generally from 10 to 11 tons in their working trim. The proportion of weight on the driving and leading wheels is various in the passenger engines, being in some 6 and 4 tons, and in others 5½ and 4½ tons; the coupled goods engines are 5¾ and 4¼ tons on the hind and leading wheels. The managers of this Company are much attached to four-wheel engines, from a conviction, by their experience, that they are equally safe, and in other respects preferable. The coupled engines, they say, work exceedingly well in all respects. One of the engines on this line (the one, I believe, which met with the accident at the Brentwood incline in the autumn of 1840), has had an additional pair of wheels placed under the fire box, as an experiment, in order to ascertain whether increased steadiness resulted from this addition. The experiment is said not to have succeeded; for although the engine works very well, she is no steadier than the sister engines, which have not had this addition.

The gross loads carried are from 32 to 35 tons. The cylinders are 12 to 14 inches diameter, stroke 18 inches, and diameter of driving wheels 5 to 6 feet. The steam pressure is 55 to 60 lbs.; the consumption of coke 33.35 lbs. to the mile, at present. This includes getting up the fire and the consumption during the long delays between the trains. Their consumption during the time of traveling must be much less, probably two-thirds of the amount. The total

expense for coke, driving, materials and labor for repairs, oil, cotton waste, tools, and all contingencies, is 11.75 pence per mile.

Some of these charges the Company expect still further to reduce, particularly the consumption of coke. At present their engines *are not worked expansively to any considerable extent.* In the engines now building for the Company they intend to use large cylinders, namely, 14 inches, with 65 lbs. steam, and to work expansively to a considerable extent, and they expect to reduce their consumption of coke by this means, and by one or two other little improvements in the engines, fully one third of the present amount.

The motions of their engines are stated to be very smooth, and whatever motion they have is attributed to the road. They have no top heavy engines. *The play on the rails is three-quarters of an inch.* The cost of an engine, including tender, is £1,600.

During the time this line has been opened, nearly three years, they have had one cranked axle broken and two engines run off the rails. The broken axle was owing to defective welding, and happened with a coupled engine, but was not then working with its couplings, though it had been a day or two before. The accident happened shortly after the engine was put upon the line. After the fracture of the axle, the engine conveyed the train a distance of two miles, which was the end of the journey; and the only indication the engine man had of the failure of the axle, was a very slight degree of collapse in the upper part of the wheels, which he thought arose from the axle being suddenly strained; and he therefore slackened his speed as a measure of precaution, and only discovered that the axle was broken when the engine arrived at the station. The accident happened on a straight line, and on ascending gradient. The diameter of the delinquent axle was 5¼ inches, cylinder 14, and stroke 18 inches.

The two cases of running off the rails are attributed to excessive speed down descending inclines, one being on a straight line, and the other on a curve of 1½ mile radius. It is estimated that the speed could not have been less than 60 miles an hour. The speed in descending the incline is now limited to 15 miles an hour, with a penalty on the men if that velocity is exceeded. This is a compliment to public prejudice, commendable enough, but not in my opinion by any means necessary. In both cases the wheels were uncoupled.

The maintainance of way on this line is performed by contract, which includes every description of work for the repair of the line, and for upholding in perfect order all the brickwork and bridges, painting all woodwork, watching the line, and all other charges of every description whatever, being, I believe, more comprehensive than almost any other contract of this description. The cost is, I understand, £214 per mile, the contractor finding materials and paint of every description.

About two miles below the Romford station the Company are now building an exceedingly commodious engine-house, where all the repairs are intended to be carried on. This structure is in the form of a double parallelogram, the longer one forming the *façade* of the

building, and the shorter parallelogram being in the same direction and immediately behind. The arrangement of this building appears to be most complete, and is considered to possess many advantages, both in cheapness of construction and convenience, over the polygon buildings, which have been erected on several other lines. By means of a very powerful traversing crane, every part of the workshop is under equal command for the purposes of any description of work connected with the engines; and the forges are detached from the general workshops. The building, when entirely finished, promises to be a complete establishment. At present, the Company are using some temporary buildings about a mile nearer to Romford, for the repairing-shops; and considering the limited room which they here possess, it is surprising to see the perfect order and extreme cleanliness of all the engines on the line.

When speaking of the signals in our last, we forgot to mention, that from these being 100 yards from the station each way, and the man being able to work them without quitting his post at the station, he can lower the signal the moment a coming-in train passes, and be ready to attend to the passengers before the train reaches the station. By this means one man does the duty of two at least, and more efficiently.

(To be continued.)

Public use of Dr. Earle's Process for preserving Timber, &c.

Sir,—The following documents do not require explanation. As they probably will not be without interest to many readers of the Journal of the Franklin Institute, they are offered for insertion, by

Your obedient servant,

Edw. Earle.

Wm. Hamilton, Esq., Actuary.

Ordnance Office,
Washington, Jan. 12, 1843.

Hon. J. C. Spencer, Secretary of War.

Sir,—I have to acknowledge the receipt of a letter from the Hon. R. H. Bayard, of the U. S. Senate, requesting to be informed of "the result of any experiments that may have been made, under the auspices of the Department, in relation to Dr. Edward Earle's method of preserving timber and cordage; together with the opinion of the Department, or of any of its officers, as to its practical value"—the same being referred to this office for a report.

The great cost of gun carriages, and the difficulty of obtaining suitable timber for their construction, induced this office, early in 1840, to consider whether the interests of the service could not be promoted by the adoption of measures to prevent their decay. "Kyanizing," and "Dr. Earle's process," were both duly considered, and the great expense of the former led to the use of the latter, by authority of the Secretary of War. Since the summer of 1840, about 70,000 cubic feet of timber have been cured at the Watervliet arsenal, the greater

part of which is deposited in store for future use. The exact cost of the operation cannot be stated, but it is believed to be about 3½ cents per cubic foot, and one and a half cents for the use of the patent right.

Sufficient time has not yet elapsed to prove the value of the process by the trials of gun carriages in service; but, during the period of operations, the person charged with supervising the curing of the timber (Mr. R. M. Bouton) has made some experiments, which are set forth in a printed paper published by Dr. Earle, which is hereto appended.

Mr. Bouton is a man possessed of much more science than is usually found in such a first rate practical mechanic, and full reliance may be placed in his statements.

Upon a careful examination of the subject, which its importance to this office, in a pecuniary view, at least, seemed to demand, I have formed the opinion:

1. That the impregnation of timber with the sulphates of iron and copper may be effected by its immersion in a proper solution of those minerals, at a very moderate heat, and with timber of any size, or ength.

2. That timber thus cured will be in a great measure incorruptible, free from the attacks of worms, and from dry rot.

3. That its strength is not reduced, and its toughness, or fibrous texture, is improved.

4. That the cheapness of the process, united to its beneficial effects, promises a great reduction in the expenditures for such objects as are susceptible to its use, among which canvas and cordage seem to occupy a prominent place; and, finally,

That this process will furnish the desideratum for the preservation of many things to which it is applicable, and should be patronized by the government.

The letter of Mr. Bayard is returned herewith.

I have the honor to be, sir, very respectfully,
Your ob't serv't,
G. Talcott, Lt. Col. Ord.

(Endorsed)
Navy Department, Jan. 17, 1843.

I unhesitatingly express my full concurrence in the opinion and recommendation of Col. Talcott, within given. I have no doubt that Dr. Earle's process might be advantageously applied to a great variety of materials used in the naval service, and that the saving to the country would be incalculably greater than the cost. I therefore strongly recommend the adoption of Dr. Earle's process, upon such terms as may be considered fair and just between him and the country.

A. P. Upshur

Bibliographical Notice.

Notice of Liebig's Agricultural Chemistry.

Translated from "Berzelius' Annual Report," by J. C. B. and M. H. B.

At a time when the general agricultural interest has received a great impulse from the excellent work of Liebig on this subject, the following extract from Berzelius' two last annual reports on the progress of chemistry, &c., where he notices this work, may not perhaps be without interest to many of our readers.

"Liebig has, during the last year, published a work entitled 'Organic Chemistry, in its application to Agriculture and Physiology,' to which I wish to direct the attention of chemists. This work treats of subjects which are of the highest interest to agriculture; and I consider it the greatest merit to have brought them forward for consideration, should they even, from the way in which the author disposes of them, have the appearance of being settled with greater certainty than they can be in the present state of our knowledge, and even, sometimes, not be in accordance with what I consider to be most probable. Thus, for instance, Liebig starts from the ideas of Decandotte and Macaire Princeps, of excretions from the roots in the soil, which should be obnoxious, or, at least, useless, to themselves, but available to other plants cultivated in the same soil. But these ideas have afterwards been tested by experiments by Braconnot, distinguished both as a chemist and physiologist, who could discover no such excretions, and showed that, in Macaire's experiments, the water in which the plants were made to grow acts very differently from a soil of the proper degree of moisture. Such ideas, contradicted by experiments, cannot be assumed as correct, and ought certainly not to be given as settled before the objections to them are disproved. Perhaps the latter may be so well founded as to render it necessary to abandon the ideas as incorrect.

"Liebig does not, moreover, consider decaying organic substances in the soil as direct food to the plants; according to him, their food consists of water, carbonic acid, and ammonia, which their parts above the soil take up from the atmosphere, and their roots absorb from the soil, as they are generated by the progressive putrefaction of organic substances, (manure, mould.) As yet, experiments to prove this are entirely wanting, and, even if this should be eventually found to be correct, it would still be too early to assume it as established. But we have a number of experiments showing that the roots take up from the soil such dilute solutions as are contained in it, and it is very natural to imagine that plants should take up such dilute solutions of organic substances, and transform them in their vessels, in the same manner as in the animal kingdom. But, although doubts may thus arise relative to the perfect correctness of several conclusions in this work, no reader will peruse it without clear views

on many points, of importance in agriculture, of which he may never have thought before."—*Årsberättelse*, 1841, p. 187.

"I mentioned in my last report the ideas of Liebig, according to which, carbonic acid, ammonia, and nitric acid, form the only materials from which plants obtain their elements, and that manures only so far serve as nourishment to them, as they produce these substances, which are the only ones they are capable of assimilating to form their organic constituents. This theory has some foundation in the fact, which has been long known, that plants decompose the carbonic acid of the air, taking up its carbon. How far, on the other hand, ammonia is capable of assisting in the formation of their nitrogen compounds, we know nothing from experiments; hence, it is merely a hypothesis, which abides experimental confirmation. But, as for that part of this theory which holds that water, carbonic acid, and ammonia, (besides nitric acid,) should be the only materials for the formation of plants, it has too much against it, in the common experience of agriculture, to be regarded even as probable."—*Årsberättelse*, 1842, p. 170.

Practical & Theoretical Mechanics & Chemistry.

Theobromin, a New Substance in the Cacao Bean. By J. C. B. *and* M. H. B.

It is generally known that tea and coffee both contain a crystalizable substance, thein and coffein, which are remarkable for their large content of nitrogen, (29 per cent.) for which reason they are supposed to play an important part in the economy of man, where these beverages have come into general use. These two substances were, at the suggestion of Berzelius, identified by Mulder. Woskressensky, (Ann. de Chemie and Pharmacy, XLI, p. 125,) not long ago, discovered a similar substance in the cacao bean, to which he gave the name of theobromin. It is obtained from raw chocolate nuts, by a similar process to that employed for the extraction of coffein from raw coffee. It forms a white crystaline powder, sparingly soluble in cold, more so in boiling, water—the latter becoming opalescent on cooling. It is soluble in alcohol, but less soluble in ether than in water. It does not combine with acids, nor bases, excepting with tannin, an excess of which dissolves it; the combination is soluble in alcohol and boiling water. An alcoholic solution of theobromin yields, with a solution of corrosive sublimate, a white crystaline precipitate, sparingly soluble in water and alcohol. The analysis of theobromin yielded

	By experiment.	Atoms.	By calculation.
Carbon,	46.705	9	46.436
Hydrogen,	4.515	5	4.211
Nitrogen,	35.381	3	35.853
Oxygen,	13.399	2	13.500

Berzelius expresses its composition by the formula $C^9 H^2 N^2 O^2 + NH^3$, and remarks (*Årsberättelse*, 1842, p. 352,) that its property to be precipitated by tannin and chloride of mercury seems to indicate that it is a vegetable base, and that, notwithstanding the assertion of Woskressensky, of its incapability of combining with acids, a closer study of its properties may prove it to belong, like thein, to that class. It is remarkable that its content of nitrogen is even greater than that of thein, or coffein, which is considered as one of the most nitrogenized compounds among vegetable substances.

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*James Nasmyth's Patent Direct Action Steam Forge Hammer.**

The truly valuable qualities possessed by wrought iron, as the material of all others the best adapted to withstand force, has rendered its use as a mechanical agent almost universal; so important are the purposes it serves in enabling man to combat with the elements, and, as it were, bend them to his will, that we may almost measure the progress of civilization in any nation by the quantity of that inestimable material they convert to their use; hence it is that Great Britain owes no small portion of her power, wealth, and mechanical supremacy, to her superior knowledge of the use and capabilities of this, the most serviceable of all substances.

National improvement is always indicated and accompanied by increased consumption (by reason of increased application) of wrought iron; by its use man first merges from the savage state, and by its extended employment the most civilized nations not only maintain, but advance in, their improvement. It is, perhaps, unnecessary here to remark how entirely we are indebted to wrought iron for the services of the steam engine, and its innumerable progeny of happy results, to say nothing of railways and steam vessels, in the very hulls of which, as well as in other ships, it is rapidly manifesting its superiority over wood, and so giving to the world another magnificent evidence of its all but universality of application. Hence it is that few mechanical improvements are of more real importance than those which relate to the manufacture of wrought iron, not only in respect to its production in the first instance, but also to our increased facilities, and means, of working it into such forms as may be rendered desirable and necessary.

By a property almost peculiar to wrought iron, namely, its all but unmeltableness, its application would have been very limited, by reason of the difficulty we should have experienced in fashioning it into any required form; but by another peculiarity, namely, its capability of being welded, we have the loss of convenience arising from its unmeltableness *more* than made up to us; and where we add to this its extreme malleability, by which property, and by the assistance of heat, it is capable of being forged into any required form, our com-

* The patent right of Nasmyth's Direct Action Steam Hammer, for the United States, is vested in Messrs. MERRICK & TOWNE, Engineers, Southwark Foundry, Philadelphia—who have received full instructions and working drawings from the inventor.

mand over it is only limited by our means of applying the requisite force, whether by compression, as in the case of the process of rolling, or by blows, as in the case of forging by the hammer; this latter process being by far the most important, not only in respect to its affording us the means of giving to masses of wrought iron the requisite shape and form, but also, when the process of hammering is carried on with due energy, *while the iron is at a welding heat*, the effect of such hammering is productive of a most important improvement in the quality of the iron, as regards its tenacity, and consequent capability of resisting strains without the risk of fracture; this gain of strength arising from the more intimate contact, or union, brought about between the particles of the iron, by reason of the more perfect expulsion of all those impurities which otherwise, by separating the particles, or fibres, of the iron, so impair its strength. Hence we have one of the many important reasons why it is so desirable that we should have the means of hammering iron, when at the proper weld ing heat, *with all due energy*, whatever be the size, or form, of the mass in question.

The great success which has attended the application of the steam engine in the case of steam ships, and in other instances, has produced a demand for enormous forgings of wrought iron, such as paddle shafts, cranks, &c., that no small difficulty is now felt in the execution of large parts of them, having attained to such a magnitude as to be all but beyond the power and capability of the largest forge hammers to execute them.

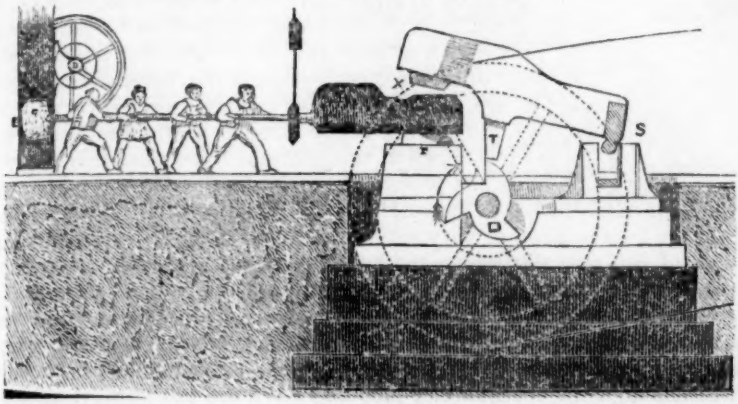
The approach of this point of ultimate capability has long been felt, not only by the vast difficulty and expense by the ordinary means, such enormous forgings being so frequently attended by the destruction of the machinery employed, but also by the frequent occurrence of unsoundness being the certain result of inadequate means, and the exceeding the limits and capabilities of the machinery hitherto employed for the purpose, arising from a defect inherent in the principle on which such machinery has been constructed, the evils of which have been rendered more and more apparent by every successive attempt to enlarge the apparatus, with a view to endeavor to enable it to cope with the increase in the magnitude of the forgings it was required to execute.

It was with the view to remove *those defects in the principle* on which such forge hammers were constructed, and to produce such a hammer as should, in the most simple manner, attain all that was desirable in our means of forging the very largest class of work, and that in a manner infinitely more convenient, perfect, and economical, that led me to contrive my *direct action steam hammer*, which I shall now proceed to describe, and which has realized my most sanguine expectations of its advantages.

In order to give such of my readers as are not minutely acquainted with the subject, a more clear view of the advantages possessed by this direct action steam hammer over those of forge hammers of the ordinary construction, I must refer them to Fig. 1, which is intended to represent a forge hammer of the largest class, and, generally, ar-

ranged according to the most improved principle. According to the scale on which this sketch is made out, such a hammer would be fully what is called a seven ton hammer, and, consequently, adapted (so far as its principles of construction will permit) for the execution of the largest class of work.

Fig. 1.—View of the Old Tilting Hammer.



One chief and universal feature in all such hammers is, that the power which causes them to rise and fall, and so give out blows on the work on the anvil, consists of *rotary motion*, which, originating in the *rectilinear* motion of the piston of the steam engine, is conveyed to the hammer by, and through, the medium of *revolving shafts*, wheels, &c., and finally re-converted into its original up and down motion by means of the cam wheel, marked D in the sketch; thus, by a very *roundabout* course, we have brought our power back again into the form it first existed, namely, rectilinear motion, or as nearly so as the radial action of the hammer will permit. And what advantage have we obtained by causing our power to travel to its object by such a roundabout course? none that I ever could see; and as to the disadvantages, they are many, and most serious. In the first place, there is great loss of power, on account of the very unfavorable manner in which the momentum of the fly-wheel on the cam shaft D communicates its motion to the helve of the hammer, by a jolting action most unfavorable to the economical communication of power; add to which the vast space of the forge shop, occupied by all the intermediate apparatus of a *complete* steam engine, with its requisite fly-wheels, shafts, beams, and *very costly foundations*, which, in order to endeavor to maintain the apparatus in due order, has to be made of more than ordinary substantiality; so much so, that, to resist the destructive effect of the vibration given to the entire machinery by the action of the hammer, the foundations have to be made so solid as to cost, in some cases, nearly as much as the whole metallic part of the apparatus.

With respect to the action of such a forge hammer, as seen in Fig. 1, it will be found that one grand defect in principle exists,

namely, that, when engaged in hammering a large piece of work, as that seen in the sketch, by reason of the work occupying the greater part of the clear space between the anvil face and that of the hammer, we have thereby a slight blow when we are doing a large piece of work, and a heavy blow when we are hammering a small, or thinner, piece of work, which is just the very reverse of what we could desire. And, in the execution of large work, this is found to be a most serious evil, inasmuch as, from the nature of the case, we would wish to have the most powerful and energetic blows that it is possible to command. The result of this is, that neither is the mass rendered so sound as we could desire, nor is it brought to its required form except by repeated heatings, at the very great sacrifice of time and iron, in so far as, ere the limited blows of the hammer have produced the required change of form, the welding heat has gone off, and all blows after this tend rather to loosen, than compact, or solidify, the mass. Again, we have another very serious evil, namely, the very confined limits of the space between the hammer face at its highest, and that of the face of the anvil, which renders it quite incapable of admitting, or operating upon, a mass of any great breadth, or height; and besides having the machinery of the hammer quite in the way, in many cases we have also this other disadvantage, namely, that, except for one thickness of work, the hammer face and anvil are not parallel, as will be evident on referring to the sketch, and considering that the face of the hammer acts radial to the centre, S, Fig. 1, in which it rocks. This evil is, to a small extent, obviated by means being given to raise up the tail, or centre, S; but this process is not only difficult, but can only be done between the heats.

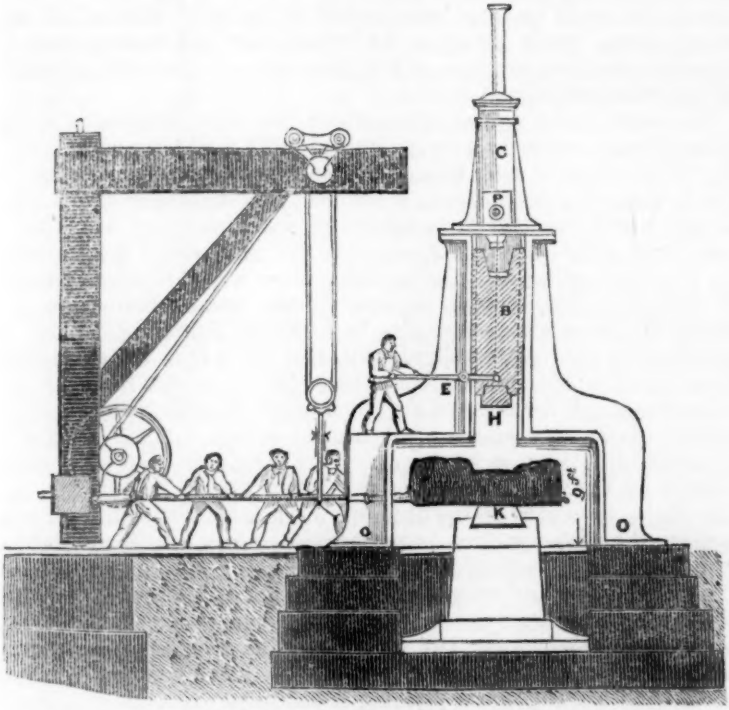
With a view to relieve all these defects, I have contrived my direct action steam hammer, which is represented, in one of its many forms and applications, in Fig. 2.

It consists simply of a cylinder, C, turned, as it were, upside down; that is, its piston rod comes out at the bottom of the cylinder, instead of (as in most cases) out of the top; this cylinder is supported over the anvil K by two upright standards, O O, the end of the piston rod being attached to a block, or mass, of cast iron, B, guided in its descent by planed guides, or ribs, cast on the edge of each standard. This block of cast iron is the hammer, or blow-giving part of the apparatus, while the cylinder, with its piston and piston-rod, supplies in the most simple, straightforward, and direct manner, the power by which the striking block, B, is lifted, or raised up. *Gravity* performs the downward action for us in a most *direct* manner. In order to set this steam hammer in action, steam of such a pressure as, operating upon the under side of the piston, will a little* more than balance the weight of the block, B, is conveyed from a suitable boiler, (situated in any convenient part of the premises,) through the pipe, P, into the valve box, in which a slide valve of the most simple form works. The valve, being up, permits the steam to press upon the under side of the piston, and up goes the block, B, *to any height* (within the limits

* About five to six per cent. more pressure than will just balance the block, gives all due activity to the upward, or lifting, action of the block.

of the length of the cylinder) which the forge man may require. The handle, E, is now moved in the contrary direction, which not only prevents any further admission of steam, but also permits that which had entered to escape by the pipe, L; the instant this is done, the block B descends with all the energy and force due to its weight and the height through which it falls, and discharges *its full and entire* momentum upon the work then on the anvil, with such tremendous effect as to set the blows of all previous hammers at utter defiance! In fact, the power of such a hammer is only limited by the size we please to make it, as *the principle* is capable of being carried out to any extent; whereas, in the case of such hammers as in Fig. 1, they have their limits, by reason of the very mass of material causing them to be weak *per se*, by the intestinal contraction of the iron which composes their mass, and which, in their action, is so destructive and trying to such a form; the consequence is, they generally break over just behind the neck.

Fig. 2.—Nasmyth's Direct Action Steam Hammer.



I have only alluded to the means which this steam hammer gives of obtaining tremendous blows. But, energetic and powerful as it is, it is at the same time one of the most striking examples of the manageability of the power of steam; inasmuch as, when we desire to

have *any variety* in the intensity of the blow, varying from the most gentle *nut*-cracking tap! to the most awful smash, we have simply to work the valve-handle in proportion, and, by so regulating the *exit* of the steam, we can let down the block, like closing a well-hung window, or *arrest its downward progress in an instant at any part of its stroke*, and retain it there at any required height, for any required time; on the other hand, by duly regulating the entrance of the steam, we can lift the block to any required height from the face of the anvil, or surface of the work, and so regulate the amount, or rapidity, of the blows accordingly.

The form and arrangement of the steam hammer, as given in Fig. 2, is such as present experience shows to be most convenient; according to the scale on which the sketch is made out, the distance between the standards O O gives a clear space of twelve feet, namely, six feet on each side of the centre of the anvil, and six feet height clear over head, as figured in the sketch. But these proportions may of course be varied at will, as the *principle* of this steam hammer affords every facility to extension, or otherwise. The space on each side of the anvil, in front and behind, being quite clear of all machinery, gives every facility to the introduction and management of the work, when we progress, as will be evident to, and fully appreciated by, practical men.

The comparatively small space which the entire apparatus of the steam hammer occupies, may be judged of by a glance at the sketch, Fig. 2, as compared with that of the ordinary construction in Fig. 1. Had I turned the standards in the sketch, Fig. 2, so as to give a *side*, or edge, view, the contrast in respect to space occupied would have been much more striking. As regards the comparative original cost, any one the least accustomed to such matters will at once see the vast advantage, in that respect, in favor of the steam hammer, to say nothing of its vast superiority as to efficiency and little liability to derangement; in fact, so simple is it, that there is scarcely anything to go wrong. One great source of its durability in this respect is the manner in which the mass of the block is raised, namely, through the medium of *the* most elastic of all bodies—steam; which, in place of any destructive jerk, as in the case of motion conveyed by impulse through solid media, so apparent and destructive in its effect in the case of the apparatus of the ordinary forge hammer, with the steam hammer the lifting motion is performed so smoothly as to be absolutely silent in its action, as if the great block had forgot, for the while, that it had any weight at all. I do not intend here to rival the celebrated Caterfelto by wondering at my own wonders! but, truly, the action of this simple, but most powerful, machine is not a little striking, both in its action as well as effect. I think experience will prove that I am not too far yielding to sanguine expectations when I state that the vast facilities which this invention gives to the treatment of large masses of wrought iron, will introduce quite a new era in the manufacture and working of wrought iron. We have now, by means of this steam hammer, a power and capability of producing forgings of wrought iron, of *any* dimensions, whose soundness will

give the best evidence of the value of the invention in that respect, and from the vast facilities of executing the most ponderous and acquired forms, the saving of time and finish which can be attained under such a hammer, will also prove that a great step has been made in the mechanical arts.

In conclusion, it may perhaps be as well to remark on the valuable and important influence which such a hammer will have upon the quality of iron, as in the case of boiler plates and such like, the quality of which, as regards *soundness*, entirely depends on the efficient manner in which they have been hammered and consolidated in the primary process of faggoting, or shingling, namely, the forming into one perfectly *solid* mass, the block of iron from which such boiler plates, &c., are rolled. Nine-tenths of the defects which are met with in boiler plates, and which have caused such disastrous results, namely, defects from blisters, have arisen from, or may be traced to, imperfect consolidation, resulting from inadequate means of hammering the original mass into a truly solid block, by our not having the *power* to force out all the scoria, which, otherwise, lodging between the pile of pieces of which the faggot is composed, gives rise to the most serious defects, which every practical man has had to deplore. It will, in like manner, be scarcely requisite that I state any of the advantages that will arise in our having, by means of the energetic action of the steam hammer, a perfect security against unsound *anchors*, the importance of which requires no words to set forth. In short, we have now at command an almost new power, inasmuch as, by means of this steam hammer, we have an accession to our means of dealing with power in the form and state of *percussion*, such as has never been attained before, and that in the most *simple*, straightforward, and *effective* manner.

Fig. 3.

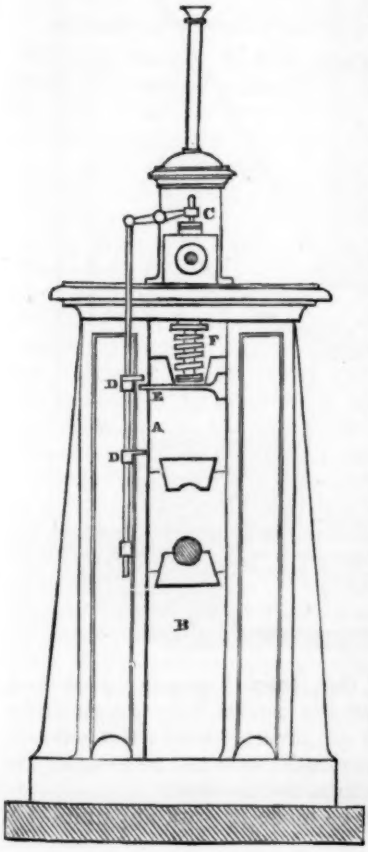


Fig. 3 shows the application of the hammer A for forging an iron shaft laid over the anvil, or block, B, and is made self-acting, as will be seen by a reference to the cut, that when the tappets D D come in contact with the pin, or spring, on the block E, the steam valve C is opened, or closed.

Fig. 4.

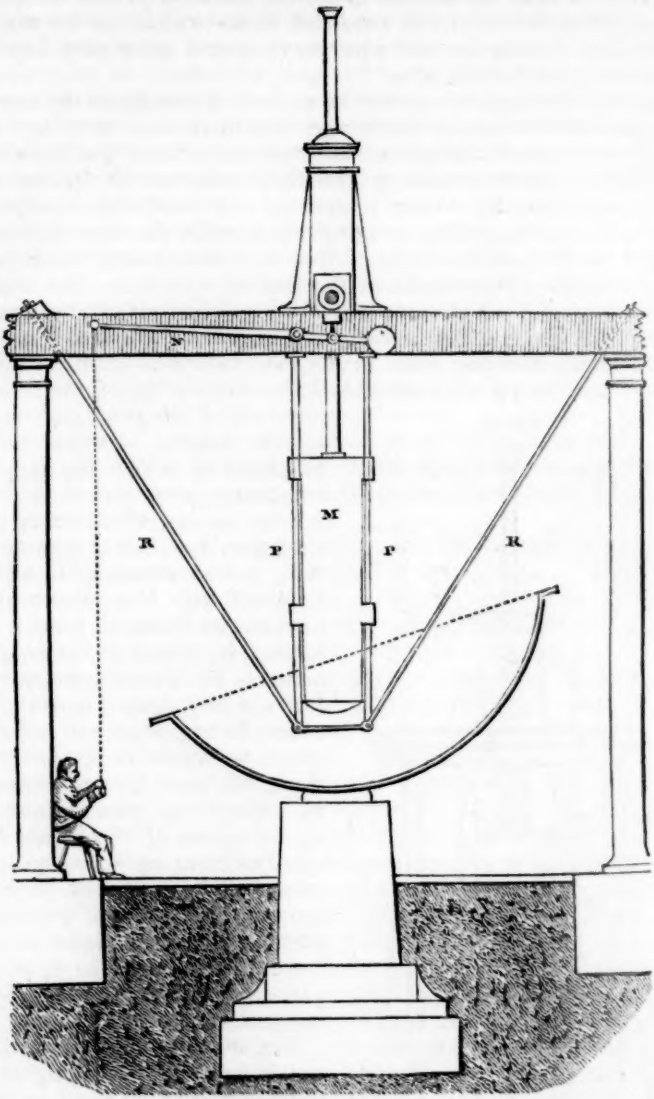


Fig. 4 shows the application of the steam hammer for coppers, pans, &c. The hammer M works in the guides P P, suspended by the rods R to the beam above, like an inverted truss; the action of the man pulling down the lever N opens the valve, so as to admit the steam for raising the piston, and, with it, the hammer.

I may remark, that one boiler can be made to work any number of

steam hammers, as the steam has only to be conducted to each by pipes, and the power let on and shut off in the same manner as gas; and in most iron forges, the waste heat of the furnace will more than furnish the requisite steam. There are many other applications and details connected with this important invention; but reluctance to further trespass on your readers' attention, and the space of your columns, causes me to defer to a future opportunity.

But I trust the high importance of the subject will plead my excuse for the length to which I have allowed my remarks to extend.

With most sincere respect,

I am, very truly, yours,

JAMES NASMYTH.

Bridgewater Foundry, Patercroft, Jan. 17.

Civ. Eng. and Arch. Jour.

The Practice of Fresco Painting.

(Continued from page 134.)

Methods of Fresco Painting, described by writers on Art.

The observations on the practice of fresco-painting by early writers on art coincide generally with the statements above given; the only point on which those writers do not appear to insist is the necessity of keeping the lime for a very long period. In other respects, Cennini and Leon Battista Alberti, in the fifteenth century; Vasari, Armenini, and Borghini, in the sixteenth century; Andrea Pozzo in the seventeenth; and Palomino in the beginning of the eighteenth, describe, more or less fully, the same process. But before referring to these writers, it may be desirable to take a glance at the ancient authorities who have described the modes of preparing walls with stucco on which fresco-paintings were executed.

Vitruvius suggests that where there is danger of damp affecting the coats of plaster, a thin (brick) wall should be carried up within and in some measure detached from the main wall.* When timber partitions were to be covered with stucco, two layers of split reeds were nailed with broad-headed nails on the upright and cross pieces, the one vertically, the other horizontally; "the double row of reeds thus crossed and firmly fixed prevents all cracks and fissures." The coats of plaster, from the rough-cast to the finished surface, were numerous, namely, after the rough-cast, three of sand and lime, and three of marble-dust and lime. The last coat was often highly polished. "When," Vitruvius afterwards observes, "only one coat of sand and lime and one of marble-dust and lime are used, the plaster is easily broken and cannot receive a brilliant polish." When frescos were added, the surface was necessarily somewhat less smooth.

The passage that follows, relating to paintings on walls, has been

* De Architect, l 7, c. 4. This is the mode in which the stuccoed and painted walls of Pompeii are constructed; the bricks, or rather tiles, are placed edgewise, and are connected by leaden cramps to the brick or tufo wall, without being in immediate contact with it.

often the subject of controversy, but when compared with the practical details of fresco, already described, it can hardly fail to be understood as referring to that method. The ancient writer's mode of accounting for certain effects is, of course, unimportant. "Colors," Vitruvius observes, "when carefully applied on moist stucco, do not therefore fade, but (on the contrary) last forever; because the same having been deprived of moisture in the kiln, and having become porous and absorbent, readily imbibes whatever (moisture) comes in contact with it; and the whole, when dry, seems composed of one and the same substance and quality. Hence stuccoed walls, when well executed, do not easily become dirty, nor do they lose their colors when they require to be washed, unless the painting was carelessly done, or executed after the surface was dry." The general evenness of the wall is here explained to be essential to the due effect of the paintings: the opposite evil, that of an undulating surface, on which dust lodges irregularly, is seen in some of the frescos of the Vatican.

This general evenness of the plaster does not suppose unpleasant smoothness of surface in the fresco; in many Italian, and indeed many antique, mural paintings, the traces of the brush often indicate a considerable body of color; but care seems to have been taken not to load the surface unequally. In a London atmosphere this comparative evenness of the surface might, on the Vitruvian principle, protect the painting longer from smoke and dust, while it would assist the operation of cleaning. But the work might be protected by other means; the plaster might be applied so that the face of the wall—at least in the portions intended to receive frescos—should not be quite perpendicular, but incline a little inwards (with reference to the room) towards the upper part. In connexion with the question of surface, it may be remarked that the hardening of the lime takes place sooner in proportion to the roughness of the surface. In plate 2 of Smith's translation of Vicat ("Résumé sur les Mortiers et Ciments Calcaires") will be found representations of sections of lime a year old, exhibiting the progress of the carbonic acid and the comparative redintegration of the original carbonate of lime. Captain Smith remarks (p. 173) "It would be difficult to credit, did we not see it, how great an obstacle a smoothness of surface presents to the penetration of the carbonic acid."

Leon Battista Alberti copies Vitruvius in many points: he observes generally that the more coats a wall receives the better the surface may be polished, and the longer it will last, and speaks of ancient examples in which there were nine successive coats. He alludes more directly to the practice of his own time when he says that no stucco should be composed of less than three coats:* these he afterwards describes. "The first rough coat," he observes, "should

* He is still so far true to the Vitruvian rules, that he speaks of each layer in the plural, as if the number of coats was indefinite. His Italian translator (Cosimo Bartoli, 1550,) reduces these half classical directions to the practices of the day, and gives the Florentine technical terms for the general expressions of Alberti; the *rinzaffato* rough-coat, the *arricciato* sand coat, and the *intonaco* (tunica) fine plaster.

be composed of pit sand and pounded bricks; the pieces of brick should not be broken too small. For the second coat river sand is best adapted, and is less apt to crack; this second coat also should be somewhat rough, because nothing that is applied to a smooth surface will adhere to it. The last coat should be as white as marble, in fact pounded white marble should be used instead of sand. This coat need not be thicker than half a finger's breadth, some make it no thicker than the sole of a shoe. In many places," he proceeds, "we find nails fastened in the wall to keep on the coats of plaster, and time has shown that they had better be of bronze than of iron. Instead of nails, I much approve the practice of inserting thin pieces of flint, projecting edgewise from the joints of the stone; these should be driven in with a wooden mallet." Various directions follow, partly derived from Vitruvius, partly from his own experience. Speaking of colors that are fit and unfit for fresco, his expressions are at once in accordance with an ancient authority,* and with modern practice; in this as in other instances Leon Battista Alberti appears as the connecting link between ancient and revived art. He speaks of the "newly-invented art of painting with linseed oil," as calculated to last for ever on walls, provided they are perfectly free from damp; on this subject he could of course have no experience. He concludes by observing that he had seen even fresh lime painted with colors prepared from vitrified substances. Cennini, who has recorded the old Florentine methods, states that "both the lime and the sand should be well sifted. If the lime is what is called a rich lime, and has been recently slaked, there should be two parts of sand to one of lime.† On being slaked it should be well mixed and stirred, and a quantity should be made, sufficient to last for 15 or 20 days. It should then be suffered to remain *for some days*, in order to render it less caustic, for if too caustic, the *intonaco*‡ will blister." The mortar composed as above serves for the first coat, the surface,

* Pliny (l. 35, c. 7) observes that certain colors, which he enumerates, are unfit for fresco (udo), but may be employed on a dry ground of gypsum (cretulam). So elsewhere (l. 33. c. 13) speaking of an artificial blue, he states that it would not stand on lime, "usus in cretâ, calcis impatiens." Andrea Pozzo observes that all colors may be used on a ground of gypsum; the word creta or its diminutive is probably to be understood here to mean gypsum; the similar Italian word is often employed in this sense. Sir Humphrey Davy observes, "the ancients were not acquainted with the distinction between aluminous and calcareous earths, and 'creta' was a term applied to every white fine earthy powder." (Philosophical Transactions for 1815, p. 112, note.) The precise meaning of creta is, however, here less important; the above passages of Pliny, together with that before quoted from Vitruvius, are sufficient to establish the fact that the ancients painted on moist lime. The analysis of some antique paintings by Sir H. Davy, confirms this.

† This is the general proportion mentioned by the ancient writers, (Cato, Vitruvius, Pliny, and Palladius,) and appears to be now commonly in use. According to some modern authorities, the proportion of sand (for general purposes) may be very much increased with advantage; see Higgins, 'Experiments and observations made with the view of improving the art of composing calcareous cements, &c., London, 1780," p. 51. But Vicat, by a series of accurate experiments, ascertained that "the resistance of mortars made from very rich limes slaked by the ordinary process, increases from 50 to 240 parts of sand to 100 of lime in stiff paste, and beyond that decreases indefinitely." (Résumé sur les Mortiers et Ciments Calcaires, p. 51.) Thus two parts and half of sand to one of rich lime are already beyond the due proportion.

‡ Cennini mentions two coats only, and applies the term *intonaco* to both.

of which is to be left somewhat rough; the application of the thinner coat or painting-ground is afterwards described, and the lime for this purpose is recommended to be well stirred and manipulated, "till it appears like ointment." The practice of painting, described by Cennini, is less important, but the allusion to glazing in fresco is worth consulting." The mode of preparing lime for the white to be used in painting, called "bianco sangiovanni," is precisely the same as that practised by modern fresco painters, and is thus described by Cennini. "Take very white slaked lime reduced to a fine powder; place it in a large tub, and mix well with water, pouring off the water as the lime settles, and adding fresh for eight days. The lime, divided into small cakes, is then placed to dry in the sun on the house-top, and the longer these cakes are left the whiter they become. To shorten the process, the cakes may be moistened again with water and well ground, and then again dried; this operation, once or twice repeated, renders the lime perfectly white." Cennini adds, "without this finely-ground white, flesh-tints and other mixed tones that may be required, cannot be executed in fresco."

Armenini describes some varieties of this process as follows:—"Take the whitest lime, such as is commonly found in Genoa, Milan, or Ravenna; this is to be well washed (purgata) before it is used; the painters prepare it in various ways; some, in order to render the lime less caustic, boil a certain quantity well on the fire, always skimming the froth; it is then suffered to cool and settle in the open air; the water is poured off, and the lime is put on new sun-baked bricks [which absorb the moisture]; and the lighter the lime the purer it is. Others bury the lime in the earth after having thus washed it, and keep it in this state many years before they use it; others expose it while undergoing the same preparation, on the roofs of houses. Some mix it in equal proportions with marble dust. But it has been found that if the lime is exposed to the air in a large vessel, and water that has been boiled is poured on it, the whole being stirred, and if the next day it is spread in the sun, it will be sufficiently purified, and may be used for painting the following day, but not for flesh-tints, for these might undergo some change at the edges (of the successive patches of plaster)."*

Speaking of retouching, Armenini observes, "in frescos which are not exposed to the weather, it is possible to give the requisite completeness by going over the work when dry." The shadows, he adds, may be finished and deepened, "by hatching, as in a drawing, with black and lake, in water-colors, using a brush of marten-hair, not too small. In diluting the colors, some use gum, some thin size, some tempera (white and yolk of egg).† He admits that in the course of time such retouchings fade.

* Director Cornelius, in addition to his opinions already given on this subject, thus expresses himself in answer to some further inquiries:—"All lime used for the first and second coats on the wall should be old, having been preserved in pits. That lime only is boiled which is used as a pigment."

† This is explained in 1. 2, c. 8 (on Tempera). "The colors are commonly mixed with thin size, and also with tempera, except the blues, which would become green, owing to the yellowness of the egg medium." It appears from Cennini (ib. p. 70,) that the yolk of egg

The descriptions of Vasari and Borghini are more concise. It might be inferred that a mixture of a certain quantity of sand with the lime must reduce the whiteness of the latter to a middle tint, but Borghini alone takes notice of this circumstance; he even assumes that a slight tint of black is added to the plaster, perhaps when the sand was of too warm a color. From the description of Leon Battista Alberti, it appears that the last coat was white, and the mixture of lime and marble-dust, mentioned by Armenini, seems to show that the same practice was sometimes followed in the 16th century. Armenini speaks also of another practice which agrees with the appearance which some of the older frescos present; he says that some painters were in the habit of covering the wall with a coat or two of white (wash) immediately before beginning, in order to give more brilliancy to the superadded colors. He disapproves of the practice, as tending to injure the effect of the shadows, but the practice itself shows that in this case the *intonaco* was not in the first instance white.

Andrea Pozzo, the author of the original of the Jesuit's Perspective, and the painter of the celebrated ceiling of S. Ignazio in Rome, and other works of the kind, added a short treatise on Fresco to his great work on Perspective.* The subject is treated under the following heads:—1. The construction of the scaffolding. 2. The application of the rough-cast (*arriccaire*): on this he observes, that the painter should never begin to work where the rough-cast has been recently laid on, especially if in interiors, on account of the moist exhalations and the smell of the lime, both of which are hurtful.† 3. The application of the *intonaco*. This is to be done when the wall is thoroughly dry; it is then well moistened as before described before the *intonaco* is laid on. "The lime used for this purpose should have been slaked *a year or six months* before, and is mixed with well-washed river sand of moderate fineness. In Rome, the painters use pozzolana, but as this is of unequal grain, it is difficult to levigate mortar composed of it, and it is impossible to stir it again after some hours; this being sometimes necessary. An expert and active mason should be selected to spread the *intonaco* equally, and to leave the painter time enough for his work within the day. 4. Roughening the surface (*granire*). The *intonaco* being equally spread, it will be well slightly to rub up with a brush the minute grains of sand, as the colors adhere better to a somewhat rough surface. This operation is essential in great works that are to be seen at a distance; it is also useful in a certain degree in near works, but

was used with the white, and even alone; the white alone was sure to crack. Armenini further observes, "the Flemish artists use size alone, because tempera has the effect of darkening the colors." The vehicles of gum, size, vinegar, and white or yolk of egg used by the moderns for tempera (or for retouching frescos), were all employed by the ancients. See Pliny, l. 35, c. 6.

* At the end of the first edition, 1693—1700. The first section, on the construction of the scaffolding, consists only of a general recommendation to attend to safety, but the work on Perspective contains some interesting descriptions of his mechanical contrivances in the execution of the extensive works in which he was engaged.

† It is evident, however, that, to avoid these evils, a month or two would be sufficient.

it will be advisable in the latter case to spread a sheet of paper over the work at last, and with the trowel slightly to press the surface; the too prominent particles of sand will then sink in and disappear. 5. Drawing. Every one knows that before beginning to paint it is necessary to prepare a drawing and well-studied colored sketch, both of which are to be kept at hand in painting the fresco, so as not to have any other thought than that of the execution. There should also be a cartoon, of the size of the intended work; this may be placed in the situation in order to judge of the effect at a distance, and to make such corrections as appear necessary." 6. Enlarging and transferring by squares. Such methods are recommended for curved and irregular portions of architecture where it may be difficult to trace from drawings. According to some passages in Cennini and Armenini, this seems to have been the practice with the early Florentines even on level walls; in this mode the squares were first marked on the rough dry mortar and repeated, (the extremities of the lines being visible on the *intonaco*). In this process time was lost, and the outline was less correct. 7. Tracing on the wall. Either with an iron point or by pouncing a pricked outline as before described. 8. The Palette. "Before beginning to paint, the colors are to be prepared as well as the intermediate tints, such at least as are wanted for one figure; indeed, if a mass of architecture is to be painted, it will be necessary to prepare a key-tint for the whole work, otherwise it will be found difficult in repeated operations (after the tints have changed in drying) to match the color. Other methods, however necessary, need not be described, as they are common to oil-painting." 9. Painting. The general observations are the same as those before given; the author suggests that a small (tin) vessel for water may be attached to the palette; he recommends not beginning to paint till the *intonaco* will barely receive the impression of the finger, otherwise the whole work will be weak, and could only serve for a first painting. 10. Painting more solidly (*impastare e caricare*). "This is peculiar to fresco, that the first colors which touch the lime immediately lose their force. It is therefore necessary to go over the work again with a greater body of color, taking care never to leave the portion allotted for the day till it is quite finished, because all retouching after a certain time will deform the work: it would be better to wait even till the wall is quite dry, and then retouch." 11. Retouching. The author admits that it is better not to retouch, but adds that as the lime always undergoes some slight change, particularly in the shadows, it is sometimes unavoidable; he observes, that such retouchings are useless in the open air, as the rain washes them away. 12. Softening. He recommends the use of soft, long brushes, not too moist, and states that the finger may be used sometimes with effect in heads when the lime begins to grow hard. He alludes to other methods for the gradation of light in glories, &c. 13. Excision and entire repainting. The possibility of such corrections, and the mode of making them, have been already alluded to. "In interiors, alterations may be made merely by repainting on the dry surface, provided such alterations are required for distant figures." 14. Coloring. General

observations on colors fit for fresco. 15. White. Lime kept a year or six months is to be thinned in water, and passed through a hair-sieve into a large vessel; the water is poured off as soon as the lime has settled: thus prepared, it is fit for painting. A list of colors follows, differing but little from that given by the older writers, and also by Prof. Hess, Director Cornelius, and Mr. Andrew Wilson. The following is Pozzo's method of preparing vermilion for fresco. "This color is altogether hostile to lime, particularly when exposed to the external air, but I have often used it for draperies in paintings executed in interiors, having first prepared it as follows:—Take pure vermilion in powder, and having placed it in an earthenware vase, pour on it the water that boils up when lime is slaked in it; the water, which should be as pure as it can be, is then poured off, and the operation is often repeated. In this manner the vermilion is penetrated with the quality of the lime, and always retains it." Cennini and Armenini, on the other hand, distinctly say that vermilion will not stand in fresco.

Palomino, in his first general account of fresco, gives a list of the principal works in that method executed by the Spanish masters in Madrid, Cordova, and Seville. His description of the method itself is fuller than those hitherto referred to in this paper; but, to avoid unnecessary repetition, it will be sufficient to quote his directions where they differ from those already given. The lime should, he says, be prepared, *if possible, four or six months* before it is used. Then, after having been passed through a hair-sieve, it is mixed with sand, quite free from clay, sifted in like manner; his directions for doing this are minute. The quantities are to be *equal*, this he had found from his own experience to be the best proportion, especially if the lime is rather fresh, but if not, the plaster may be composed of three parts of lime to two of sand. This stucco is to be kept in a large tub, in which it may be conveniently stirred; it is to be kept quite moist, and remains covered with water. If the work to be executed is extensive, it will be well to prepare more than one tub; thus while the first is being used, the additional provision may be duly tempered. In this state it is to be stirred and beaten daily, taking care to remove the pellicle which remains on the surface of the water; thus prepared, it becomes perfectly mild and of the consistence of lard, it no longer injures the colors, nor, in passing from the wet to the dry state, is it liable to those changes which sometimes disappoint the most expert. "Three things are essential in the rough-cast before applying this *intonaco;* first, that it should be perfectly dry, otherwise saltpetre will appear; next, that it should be generally level though rough, for if not the *intonaco* will be unequally thick, and will crack where it is thickest; thirdly, that it should be well wetted before applying the *intonaco.*" The author even recommends wetting the portion to be painted, the evening before, especially in summer. "The *intonaco* should be about the thickness of a dollar.* After it is well spread, the assistant is to go over it with a roll of soft, wet linen, to get rid of the extreme smoothness, to remove the traces of

* The particular coin mentioned is the "real de à ocho."

the trowel, and slightly to stir the sand. The surface is next to be lightly passed over with a handkerchief to remove the particles of sand which are on the surface, and which, in painting ceilings," the author observes, "might get into the eyes. Care must be taken in tracing the first portion of the composition, to fix the paper precisely in the right place, because the subsequent lines depend on the first; for this purpose, the whole drawing had better be first fitted to the space before it is cut up for the convenience of tracing." The drawing—in this instance a picked outline—is pounced with a bag of pounded charcoal; the edge of the portion first applied should also be pounced as a guide where to cut off the superfluous *intonaco:* it is, however, cut away not close to the lines so marked, but about two fingers' breadth from it, to avoid cracks and to ensure the completion of the portion traced to the very edge: (the remainder of the superfluous *intonaco* is not to be scraped away till the day's work is done.) The dotted outline left by the pouncing is then to be gone over with black chalk, which will at once leave a dark line, and at the same time slightly indent the surface; so that if, in painting, the chalk line should disappear, the indented one will still serve as a guide. In describing this method, the author alludes to the old method of tracing with a wooden point, and alludes to frescos thus drawn in the Palace del Pardo. He speaks of the finished cartoons of Michael Angelo, Raphael, the Carracci, and others, but observes (and here the degeneracy of his age appears), that since their time artists had become impatient of so much toil, having found that their enthusiasm evaporated before the period arrived for the execution of the painting.

The surface is now to be again lightly wiped with a handkerchief to remove the charcoal that might remain; it is then to be sprinkled with water with a plasterer's large brush; this and a vessel of clean water are to be kept at hand, as the same operation may require to be often repeated, especially in summer. Another brush and a separate vessel of water should be kept for washing out any work which may require to be effaced; the water in this second vessel becomes gradually tinged with lime, and cannot serve for sprinkling the work as it would leave white spots. In frosty weather it is necessary to keep these vessels on the fire, and the assistant should use warm water in first preparing the wall. "If," the author continues, "owing to extreme cold, the surface of the *intonaco* freezes, the effect is worse than rapid drying, for no absorption takes place, and the colors afterwards crumble off like ashes, as I have myself experienced. If, therefore, the use of warm water is not sufficient to prevent such effects, it will be better to wait for milder weather." The list of colors does not materially differ from those already given, but the qualities and changes of the various pigments in fresco and the best modes of employing them are minutely described. Vermilion, the author says, will stand if passed over terra rossa. The preparation of the lime for mixing with the colors is the same as that already mentioned; the composition of the principal tints and their preparation immediately before employing them, are described.

A close, silk sieve is recommended in preparing the white for the palette. If the lime be too fresh, its causticity may be reduced by mixing finely-ground marble dust with it. A large palette of well-prepared *canvas* is proposed on account of its lightness; the palette is cleaned from time to time with a sponge. In the execution, the back ground and more distant portions of the work allotted for the day are to be put in first; the observations on these practical details are copious and useful; the tints may be softened, if desired, so as to equal the union of oil-painting by means of a moderately moistened brush.

For retouching, the author recommends goats' milk or common milk thinned with water, and mentions some colors that may be employed:* Luca Giordano, he adds, retouched with white of egg. It appears from the author's experience (and this is confirmed by modern practice), that retouchings are most necessary at the junctions of the successive patches of the *intonaco.*

The author remarks that the old masters went over the *intonaco* with a general tint of white and terra rossa before they began to paint, to render the surface more even; the operation, before described, of pressing and smoothing the surface by means of paper, was, he states, practised by them at last, when the day's work was quite completed. He concludes with some observations of cupola-painting, and on the constructions of scaffoldings.

From the report of Cavaliere Agricola on Raphael's frescos in the Vatican, it appears that the effect of those paintings was originally much heightened by retouching, some of which have faded. Thus in the architecture of the "School of Athens," the masses of light and dark only were put in fresco, but the minuter forms and mouldings were added in water-colors when the fresco was dry: a similar double operation is observable in white draperies.† In some instances even colored retouchings are apparent; these are introduced in the mode described by Armenini, not in masses, but by means of hatching (employing lines as in shading a drawing); one of the cardinals in the subject of "Attila" is thus finished. Such retouchings appear to be distinct from those added by Carlo Maratti. Lond. Athenæum.

Qualities of Iron and Steel.

At a late meeting of the Geological and Polytechnic Society of Yorkshire, the Rev. Dr. Scoresby read a paper on "A Practical Method of Determining the Qualities of Iron and Steel." The lecturer observed that the principle which he had to submit to them bore on

* Some blues are best added when the wall is dry; thus it is related that when the Pope compelled Michael Angelo to remove the scaffolding from the Capella Sistina, the retouching of ultramarine had not been added. See Condivi, Vita di Michaelangelo.

† These methods appear to have been the remains of the early Florentine practice. Cennini says, "Every thing which is executed in fresco requires to be finished and retouched when dry in tempera." (Ib. p. 74, and note.) The frescos of the early Italian painters were in fact half tempera-paintings. Merimée (De la Peinture à l'Huile, p. 310) appears to be in error in supposing that Cennini directs certain colors to be mixed with tempera when used on the wet lime. The Italian artists, no doubt, alluded to the second operation.

the determination of the different qualities of the different numbers, or kinds, of cast-iron and malleable iron as produced from our different ores in this neighborhood. In order, however, to render the subject intelligible, and the process satisfactory, he thought it would be useful to develope, in the outset, the principles upon which the mode of determining the qualities of the different substances was founded; for the methods of inductive science required that they should, at all events, be enabled to see some relation between the cause and the effect, the means and the end. After stating some particulars with respect to the nature of the magnetic power on which the determination depended, he proceeded to enumerate the foundation principle in his processes for determining the quality of iron—that whereas ferruginous substances generally were capable of the magnetic condition, those most perfectly ferruginous, or of the purest iron, were capable of the highest development of magnetic condition. If he brought a piece of cast-iron to the magnet, it would be found that it exhibited the magnetic character in a much inferior degree to that which malleable iron did. He might show that a piece of steel would exhibit it, by mere contact, in a slighter degree than iron. (Dr. Scoresby took a piece of steel and placed it beside the magnet, after which it suspended a small key.) There was there a less tendency to get magnetism by juxta-position than in iron, but there was a greater tendency to retain it; for whilst the iron lost its power by removal from the magnet, the steel did not. The more imperfect the iron, as in ores having perhaps one-third, or two-thirds, or five-sixths, of earthy substance—the more it was in a state of oxide—the less were its capabilities for showing the magnetic action. If they took cast-iron they would find a susceptibility of the magnetic influence, but in a degree of capability very different from that of malleable iron. If they took malleable iron, of a quality pure and soft, they would find the highest capacity for the magnetic condition. Now, when he discovered that any portion of ferruginous substance in a body rendered that substance capable of magnetic development, and when he knew that malleable iron generally exhibited that in the highest degree, then he drew the inference, that that which was most perfectly iron would show the highest development of the magnetic condition; and, therefore, that the iron which should exhibit the highest magnetical capabilities would be the best quality of iron. There were two methods by which, on these principles, they might determine the quality. (The Rev. gentleman then placed upon a stand a magnetic needle, or compass, having at the end a small graduated card as a scale. He then took up a small flat magnet and two small flat pieces of iron.) He had there two pieces of iron from the Bowling works; they were marked B and L, B being the mark for the best iron, and L iron of the lowest quality. He had also a superior steel magnet of the same size. (He then opposed the magnetic steel bar to the compass at some distance, and placing in succession upon it the iron plates B and L, he found that the needle receded from the magnetic iron with L upon it further than from B, though placed at equal distances.) Thus, upon the principle that he had asserted, the B

iron, which fetched the highest price in the market, and which cost more in the manufacturing, appeared, from its greater neutralizing effect on the magnet, to be a more perfect quality of iron, to have less crude matter in it, or to be more purely ferruginous than the other. For, just as he had anticipated, the bar B proved to have higher capabilities of magnetic influence than the bar L. In order to ascertain this more conclusively, he had got half a dozen plates of each kind of iron made, in order to get a mean result, which would be more accurate than that obtained from a single specimen.

To illustrate his method of determining the capacity of the several plates of iron for magnetism, as shown by their respective neutralizing action on the steel magnet of like dimensions, the Rev. gentleman showed that the action of the magnet alone upon the compass, at the distance of fifteen inches, produced a deviation in the needle from the proper meridian of about 20 deg., or two such magnets together of 31 deg. 15 min. Having, with the series of iron plates kindly furnished him by the managers of the Bowling Works, placed each of them in succession betwixt a pair of small magnetic steel plates, he found the average effect at the same precise distance to be, that the plate L reduced the action of the magnets on the compass to 8 deg. 2 min., and the plate B to 6 deg. 45 min., so that the mean reduction of power (the measure of the magnetic capacity) by L was 31 deg. 15 min—8 deg. 25 min.=22 deg. 50 min., and by B. was 31 deg. 15 min.—6 deg. 45 min.=24 deg. 30 min. Thus showing that the best iron had decidedly the highest magnetic capacity, and that the magnetic capacity of each kind had an analogous relation to the respective values of these two articles in commerce. Dr. Scoresby then went on, by the application of another principle, to investigate the quality of cast iron. For that purpose he had obtained six or seven sets of the same size of the two extreme qualities. One consisted of the best quality of cast-iron, the other was of inferior quality. They were of the qualities usually marked 1 and 3. There might be a considerable variety in No. 1 and 3; but the difference between 1 and 3 was sufficiently characteristic. There was also a considerable difference betwixt the two classes in price, as well as quality. No. 1 had less oxygen and a larger portion of carbon than No. 3, being of a purer description. Without going particularly into the chemical constituents of iron, he might just observe, that as the best quality of iron had, in the other case, the highest magnetic principle, he expected he should, in this case of cast-iron, find a similar law. He treated it, however, in a different manner. He got the plates cast in the same way, in "green sand," so that they should be very hard, and might exhibit more of the nature of steel. His plan was to try them by magnetizing them and converting them into real magnets, being of opinion that as the best steel produced the best magnets, so the best cast-iron would produce the best magnets. His first experiment was by magnetising them separately, and then carefully trying their powers by the compass. One kind, No. 1, had the power of causing the compass to diverge, on an average, 13 deg. 41 min., while No. 3 only caused it to diverge 13 deg. 7 min.—the dif-

ference between the two being as 136 to 100. Thus it appeared that the best iron had a power about one-third greater than the power of the inferior. But he tried it another way. Having found that the accumulating magnetic capabilities of substances, in relation to their number, became another test of quality, he began to try them one upon another, taking the exact quantity the compass diverged after each addition. He put a second of the best quality, and found that the divergence of the compass was about 18 deg., while No. 3 was only 12 deg. 30 min. Six plates of the best cast-iron thus combined, produced a deviation of 25 deg. 47 min., while the inferior only produced a deviation of 17 deg. 44 min., being 8 deg. less than the deviations of the best series. He did not mean to say that the theory was established on which this principle of testing cast-iron was founded; it would require many more experiments; but yet, so far as his experiments had gone, the object he had in view was fully realized, for it had been shown that they could detect quality by a scientific mode, without breaking into metal—they could discern the different qualities, in the kinds he had compared, to a nicety, equal to that which would be shown by weighing 15s. in gold, and a sovereign. The lecturer next proceeded to the application of the principle to the determining of the quality of steel. With regard to wrought-iron, it had been shown to have no permanent capabilities for retaining magnetic influence; it retained it so little that its retentiveness afforded no practical test of quality. When they tried steel, however, they found a certain permanency—no matter what might be the condition or quality of the steel, whether hard or soft, good or bad, it was capable of permanent magnetism. (He then took up two pieces of steel.) He had there a piece of steel of a very fine quality and very soft; he had given it the magnetic power. He had also another piece of steel of like quality but perfectly hard, and it was also a magnet. Now herein steel exhibited a peculiar difference from iron in its magnetic properties. Iron was capable of more magnetism when it was in contact with a magnet; but steel retained it on its removal from the magnet, whilst iron lost it. If iron would not retain the magnetic influence while steel would, he first came to this conclusion, that that which was most perfectly steel would retain the most power (that is in like condition of hardness), and that that which had the least carbonaceous matter in it would be the least permanent. (Dr. Scoresby illustrated this principle by many experiments, and then proceeded to explain his process for the determination of the hardness and temper of steel). He stated that the principle had long been held, that the harder the steel the more permanent the magnet. The truth of this he had tried in many experiments, and had always found it so. And now he came to the practical rule for knowing the hardness by the magnetic tenacity. If it was true that the hardest steel made the most permanent magnets, then it was only necessary to obtain a knowledge of the degree of permanency as the measure of the hardness.—[He then magnetised two needles of similar quality, but different in hardness, and compared the weights which they respectively bore after being subjected to the action of

the test-bar—when one had lost a little, the other the whole.]—Hence, he came to this conclusion, that the former was the hardest; which, on trial by other means, was proved to be the fact. He then applied the test of the deviation of the compass, and showed also, by this means, that the hardness of the steel might be discovered with great minuteness; so that, of 100 bars, or plates, of the same kind, as to quality, they could easily be arranged in the order of their respective degree of hardness. Mining Jour.

On Thermography, or the Art of Copying Engravings, or any Printed Characters, from Paper, on Metal Plates; and on the recent Discovery of Moser, relative to the formation of Images in the Dark. By ROBERT HUNT, *Secretary of the Royal Cornwall Polytechnic Society.*

The Journal of the Academy of Sciences of Paris, for the 18th of July, 1842, contains a communication, made by M. Regnault, from M. Moser, of Königsberg, "Sur la formation des images Daguerriennes," in which he announces the fact, that, "*when two bodies are sufficiently near, they impress their images upon each other.*" The Journal of the 29th of August contains a second communication from M. Moser, in which the results of his researches are summed up in twenty-six paragraphs. From these I select the following, which alone are to be considered on the present occasion.

"9. All bodies radiate light, even in complete darkness.

"10. This light does not appear to be allied to phosphorescence, for there is no difference perceived, whether the bodies have been long in the dark, or whether they have been just exposed to daylight, or even to direct solar light.

"10. Two bodies constantly impress their images on each other, even in complete darkness.

"14. However, for the image to be appreciable, it is necessary, because of the divergence of the rays, that the distance of the bodies should not be very considerable.

"15. To render the image visible, the vapor of water, mercury, iodine, &c., may be used.

"17. There exists *latent light*, as well as latent heat."

The announcement, at the last meeting of the British Association, of these discoveries, naturally excited a more than ordinary degree of interest. A discovery of this kind, changing, as it does, the features, not only of the theories of light adopted by philosophers, but also the commonly received opinions of mankind, was more calculated to awaken attention than any thing which has been brought before the public since the publication of Daguerre's beautiful photographic process. Having instituted a series of experiments, the results of which appear to prove that these phenomena are not produced by *latent light*, I am desirous of recording them.

I would not be understood as denying the absorption of light by bodies; of this I think we have abundant proof, and it is a matter

well deserving attention. If we pluck a Nasturtion when the sun is shining brightly on the flower, and carry it into a dark room, we shall still be enabled to see it by the light which it emits.

The human hand will sometimes exhibit the same phenomenon, and many other instances might be adduced in proof of the absorption of light, and, I believe, indeed, of the principle that light is latent in bodies. I have only to show that the conclusions of M. Moser have been formed somewhat hastily, being led, no doubt, by the striking similarity which exists between the effects produced on the Daguerreotype plates, under the influence of light, and by the juxtaposition of bodies in the dark, to consider them as the work of the same element.

1. Dr. Draper, in the Philosophical Magazine for September, 1840, mentions a fact which has been long known, "That if a piece of very *cold* clear glass, or, what is better, a *cold*, polished, metallic reflector, has a little object, such as a piece of metal, laid on it, and the surface be breathed over once, the object being then carefully removed, as often as you breathe again on the surface, a spectral image of it may be seen, and this singular phenomenon may be exhibited for many days after the first trial is made." Several other similar experiments are mentioned, all of them going to show that some mysterious molecular change has taken place on the metallic surface, which occasions it to condense vapors unequally

2. On repeating this simple experiment, I find that it is necessary, for the production of a good effect, to use dissimilar metals; for instance, a piece of gold, or platina, on a plate of copper, or of silver, will make a very decided image; whereas copper, or silver, on their respective plates, gives but a very faint one; and bodies which are bad conductors of heat, placed on good conductors, make decidedly the strongest impressions when thus treated.

3. I placed upon a well-polished copper plate, a sovereign, a shilling, a large silver medal, and a penny. The plate was gently warmed by passing a spirit lamp along its under surface; when cold, the plate was exposed to the vapor of mercury; each piece had made its impression, but those made by the gold and the large medal were most distinct; not only was the disk marked, but the lettering on each was copied.

4. A bronze medal was supported upon slips of wood, placed on the copper, one-eighth of an inch above the plate. After mercurialization, the space the medal covered was well-marked, and for a considerable distance around the mercury was unequally deposited, giving a shaded border to the image; the spaces touched by the [mercury?] were thickly covered with the vapor.

5. The above coins and medals were all placed on the plate, and it was made too hot to be handled, and allowed to cool without their being removed; impressions were made on the plate in the following order of intensity,—gold, silver, bronze, copper. The mass of the metal was found to influence materially the result; a large piece of copper making a better image than a small piece of silver. When this plate was exposed to vapor, the results were as before (3,

4.) On rubbing off the vapor, it was found that the gold and silver had made permanent impressions on the copper.

6. The above being repeated with a still greater heat, the image of the copper coin was, as well as the others, most faithfully given, but the gold and silver only made permanent impressions.

7. A *silvered* copper plate was now tried with a moderate warmth (3). Mercurial vapor brought out good images of the gold and copper; the silver marked, but not well defined.

8. Having repeated the above experiments many times with the same results, I was desirous of ascertaining if electricity had any similar effect; powerful discharges were passed through and over the plate and disks, and it was subjected to a long-continued current without any effect. The silver had been cleaned off from the plate (7), it was now warmed with the coins and medals upon it, and submitted to discharges from a very large Leyden jar; on exposing it to mercurial vapor, the impressions were very prettily brought out, and strange to say, spectral images of those which had been received on the plate when it was silvered (7); thus proving that the influence, whatever it may be, was exerted to some depth in the metal.

9. I placed upon a plate of copper, blue, red, and orange colored glasses, pieces of crown and flint glass, mica, and a square of tracing paper. These were allowed to remain in contact half an hour. The space occupied by the red glass was well marked, that covered by the orange was less distinct, but the blue glass left no impression; the shapes of the flint and crown glass were well made out, and a remarkably strong impression where the crown glass rested on the tracing paper, but the mica had not made any impression.

10. The last experiment repeated, after the exposure to mercurial vapor; heat was again applied to dissipate it; the impression still remained.

11. The experiment repeated, but the vapor of iodine used instead of that of mercury. The impressions of the glasses appeared in the same order as before, but also a very beautiful image of the mica was developed, and the paper well marked out, showing some relation to exist between the substances used and the vapors applied.

12. Placed the glasses used above (9, &c.) with a piece of well-smoked glass for half an hour, one twelfth of an inch below a polished plate of copper. The vapor of mercury brought out the image of the smoked glass only.

13. All the glasses were placed on the copper and slightly warmed; red and smoked glasses gave after vaporization, equally distinct images, the orange the next; the others left but faint marks of their forms; polishing with Tripoli and putty powder would not remove the images of the smoked and red glasses.

14. An etching, made upon a smoked etching ground on glass, the copper and glass being placed in contact. The image of the glass only could be brought out.

15. A design cut out in paper was pressed close to a copper plate by a piece of glass, and then exposed to a gentle heat; the impression was brought out by the vapor of mercury in beautiful distinct-

ness. On endeavoring to rub off the vapor, it was found, that all those parts which the paper covered, amalgamated with mercury, which was removed from the rest of the plates; hence there resulted a perfectly permanent white picture on a polished copper plate.

16. The colored glasses before named (9, 12) were placed on a plate of copper with a thick piece of charcoal, a copper coin, the mica and the paper, and exposed to a fervent sunshine. Mercurial vapor brought up the images in the following order: smoked glass, crown glass, red glass, mica beautifully delineated, orange glass, paper, charcoal, the coin, blue glass; thus distinctly proving that the only rays which had any influence on the metal, were the calorific rays. This experiment was repeated on different metals, and with various materials, the plate being exposed to steam, mercury and iodine; I invariably found that those bodies which absorbed or permitted the permeation of the most heat gave the best images. The blue and violet rays could not be detected to leave any evidence of action, and as spectra imprinted on photographic papers by light, which had permeated these glasses, gave evidence of the large quantity of the invisible rays which passed them freely, we may also consider those as entirely without the power of effecting any change on compact simple bodies.

17. In a paper which I published in the Philosophical Magazine for October, 1840, I mentioned some instances in which I had copied printed pages and engravings on iodized paper, by mere contact and exposure to the influence of the calorific rays, or to artificial heat. I then, speculating on the probability of our being enabled by some such process as the one I then named, to copy pictures and the like, proposed the name of THERMOGRAPHY, to distinguish it from Photography.

18. I now tried the effects of a print in close contact with a well-polished copper plate. When exposed to mercury, I found that the outline was very faithfully copied on the metal.

19. A paper ornament was pressed between two plates of glass, and warmed; the impression was brought out with tolerable distinctness on the under and warmest glass, but scarcely traceable on the other.

20. Rose leaves were faithfully copied on a piece of tin plate, exposed to the full influence of sunshine, but a much better impression was obtained by a prolonged exposure in the dark.

21. With a view of ascertaining the distance at which bodies might be copied, I placed upon a plate of polished copper a thick piece of plate glass, over this a square of metal, and several other things, each being larger than the body beneath. These were all covered by a deal box, which was more than half an inch distant from the plate. Things were left in this position for a night. On exposing to the vapor of mercury it was found that each article was copied, the bottom of the deal box more faithfully than any of the others, the grain of the wood being imaged on the plate.

22. Having found by a series of experiments that a blackened paper made a stronger image than a white one, I very anxiously tried to

effect the copying of a printed page or a print. I was partially successful on several metals, but it was not until I used copper plates amalgamated on one surface, and the mercury brought to a very high polish, that I produced any thing of good promise. By carefully preparing the amalgamated surface of the copper, I was at length enabled to copy from paper, line engravings, wood cuts and lithographs, with surprising accuracy. The first specimens produced (which I have the satisfaction of now submitting to your inspection), exhibit a minuteness of detail and sharpness of outline quite equal to the early Daguerreotypes and the photographic copies prepared with chloride of silver.*

The following is the process at present adopted by me, which I consider far from perfect, but which affords us very delicate images.

A well polished plate of copper is rubbed over with the nitrate of mercury, and then well washed to remove any nitrate of copper which may be formed; when quite dry a little mercury taken up on soft leather or linen is well rubbed over it, and the surface worked to a perfect mirror.

The sheet to be copied is placed smoothly over the mercurial surface, and a sheet or two of soft, clean paper being placed upon it, it is pressed into equal contact with the metal by a piece of glass, or flat board; in this state it is allowed to remain for an hour or two. The time may be considerably shortened by applying a very gentle heat for a few minutes to the under surface of the plate. The heat must on no account be so great as to volatilize the mercury. The next process is to place the plate of metal in a closed box, prepared for generating the vapor of mercury. The vapor is to be slowly evolved, and in a few seconds the picture will begin to appear; the vapor of mercury attacks those parts which correspond to the white parts of the printed page or engraving, and gives a very faithful, but somewhat indistinct image. The plate is now removed from the mercurial box, and placed into one containing iodine, to the vapor of which it is exposed for a short time; it will soon be very evident that the iodine vapor attacks those parts which are free from mercurial vapor, blackening them. Hence there results a perfectly black picture contrasted with the gray ground formed by the mercurial vapor. The picture being formed by the vapors of mercury and iodine, is of course in the same state as a Daguerreotype picture, and is readily destroyed by rubbing. From the depth to which I find the impression made in the metal, I confidently hope to be enabled to give to these singular and beautiful productions a considerable degree of permanence, so that they may be used by engravers for working on.

It is a curious fact that the vapors of mercury and of iodine attack the plate differently, and I believe it will be found that vapors have some distinct relation to the chemical, or thermo-electrical state of the bodies upon which they are received. Moser has observed this, and

* The first faithful copy of the lines of a copper-plate engraving was obtained by Mr. Cantabrana, who has since succeeded in procuring some tolerable specimens on unamalgamated copper, which cannot be rubbed off.

attributes the phenomena to the colors of the rays, which he supposes to become latent in the vapor on its passing from the solid into the more subtile form. I do not however think this explanation will agree with the results of experiments. I feel convinced that we have to deal with some thermic influence, and that it will eventually be found that some purely calorific excitement produces a molecular change, or that a thermo-electric action is induced, which effects some change in the polarities of the ultimate atoms of the solid.

These are matters which can only be decided by a series of well-conducted experiments, and, although the subject will not be laid aside by me, I hope the few curious and certainly important facts which I have brought before you, will elicit the attention of those whose leisure and well-known experimental talents qualify them in the highest degree for the interesting research into the action of those secret agents which exert so powerful an influence over the laws of the material creation. Although attention was called to the singular manner in which vapors disposed themselves on plates of glass and copper, two years since, by Dr. Draper, Professor of Chemistry at New York, and about the same time to the calorific powers of the solar spectrum, by Sir John Herschel, and to the influence of heat artificially applied, by myself (17), yet it is certainly due to M. Moser of Konigsberg, to acknowledge him to be the first who has forcibly called the attention of the scientific world to an inquiry which promises to be as important in its results as the discovery of the electric pile by Volta.

As to the practical utility of this discovery, when we reflect on the astonishing progress made in the art of photography since Mr. Fox Talbot published his first process, what may we not expect from thermography, the first rude specimens of which exhibit far greater perfection than the early efforts of the sister art?

As a subject of pure scientific interest, thermography promises to develope some of those secret influences which operate in the mysterious arrangements of the atomic constituents of matter, to show us the road into the yet hidden recesses of nature's works, and enable us to pierce the mists which at present develope some of the most striking phenomena, which the penetration and industry of a few "chosen minds" have brought before our obscured visions. It has placed us at the entrance of a great river flowing into a mighty sea, which mirrors in its glowing waters some of the most brilliant stars which beam through the atmosphere of truth. Philos. Mag.

Mr. Baggs' Carbonic Acid Gas Engine.

The theory of the new power engine, which we have now to bring under the notice of our readers, is principally based on the discoveries of modern chemistry; and it may be as well, in a few words, to advert to these discoveries, before entering into the details of Mr. Baggs' application of them.

It is generally known, that many of those gases, which were

formerly deemed permanently aëriform, are not so in fact, an alteration in their physical constitution being really effected by specific variations of pressure and temperature. Carbonic acid gas assumes the liquid form under a pressure of 36 atmospheres, or 540 lbs. to the inch, at a temperature of 32°. Ammoniacal gas becomes liquid under a pressure of 6.5 atmospheres, at the temperature of 50°; and very slight increments of heat are sufficient to exalt the elasticity of these bodies to such an extent, as to render them competent agents for the movement of machinery.

Attempts have accordingly been made to substitute their powers for those of steam, but, as yet, with no succesful result; the failure being mainly attributable to a want of economy in their production. Now, if we could manage, by any means, to *recover* these gases after they had done duty in the cylinder of an ordinary engine—if we could only save them from running to waste, cause them to perform their office over and over again, and effect all this at a small expense, it will be obvious that the great difficulty which has stood in the way of previous experimentalists would be avoided, and we should have at command an exceedingly cheap and portable power. This, then, is what Mr. Baggs has done; or, at least, shown the means of doing.

Mr. Baggs proposes to *generate the gas through the medium of a fixed acid, and a carbonate of the volatile alkali.* For instance: by pouring *phosphoric acid* upon carbonate of ammonia, *phosphate of ammonia* is produced, and carbonic acid gas is driven off; and by subjecting this phosphate of ammonia to heat, it is decomposed, ammoniacal gas is liberated, and the phosphoric acid originally employed in the first part of the process remains behind. Here, then, is the regeneration of one of the materials by the aid only of a small quantity of fuel; and the recovery of the other is even more simple. The carbonic and ammoniacal gases, produced as above described, after performing the office of steam in an appropriate engine, are allowed, by virtue of their non-elasticity, to rush into an exhausted receiver, where they no sooner come into contact than immediate condensation ensues, with the reproduction of the exact quantity of carbonate of ammonia destroyed in the commencement of the process.

It will be observed that there are but *three* proximate elements concerned throughout—phosphoric acid, carbonic acid, and ammonia, which, by the consecutive influences of chemical affinity and caloric, are made to undergo a definite series of actions amongst themselves, with the resulting evolution of an enormous mechanical power.

With regard to the acid employed, Mr. Baggs does not consider it to be essential that the phosphoric should be used; any *fixed* acid will answer the purpose, and the boracic and sulphuric acids are offered as examples. The question of preference is one of economy alone. Phosphoric acid is one of the principal constituents of bones, and the process for its extraction is sufficiently simple. Boracic acid is found native, and may also be obtained in abundance from borax. Sulphuric acid, it is well known, is plentiful enough; and with reference to the other ingredient, carbonate of ammonia, the sources of its supply are perpetual, cheap, and abundant.

Supposing the invention to be applied to a locomotive, Mr. Baggs proposes to adopt the following routine. At any given station or line of stations, proper arrangements are to be made for carrying on the manufacture of gases in the way we have described. As the latter are produced they are to be condensed into a liquid form, either by the chemical process of Dr. Faraday, or by the mechanical method of compression, which originated with Sir M. Isambard Brunel. The two liquids thus obtained would form the only load which the engine would be required to carry; and the carbonate of ammonia would be re-formed *on the road* as the liquids were expended. All the other parts of the process are to be conducted at the station.

The condensation of the gases will be attended by the evolution of a great quantity of caloric, and, in order to reduce the amount of this in the condenser, as well as to increase the elasticity of the gases before they enter the working cylinders, the induction pipes are made to embrace the condenser.

By the transfer of caloric (thus effected) from the interior to the exterior of the condenser, the pressure within will be lessened, and that without increased, the power being thereby nearly doubled. When the stock of liquid material is consumed, it is to be replenished at the station; and the carbonate of ammonia is to be withdrawn from the condenser, by the removal of one of the hemispherical ends.

Another mode of employing the condenser, which Mr. Baggs points out, is by effecting a solution of the salt which it contains, and allowing the liquid to flow out. Lond. Mech. Mag.

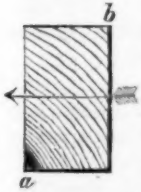
Wrought Iron Axles.

Sir—It is worthy of remark how slowly well proved facts, individually acknowledged and acted upon, become generally admitted; it is to be regretted that we are not more communicative of those events which strike us in our daily practice, and which, if announced as soon as discovered, would so materially and rapidly tend to general improvement. There is, perhaps, no instance in which this can be more clearly exemplified than in the use of wrought iron; it is scarcely possible to refer to the subject without an example being readily laid before you. Every manufacturer has had, more or less, his attention drawn to the fact, that in its various applications wrought iron is subject to become brittle. Iron spindles, piston rods, fire bars, crow bars, chisels, and many other things, are known to lose their fibrous quality after being in use for a length of time, varying according to the nature of the service they have had to perform. By some it has been considered that the iron originally employed was of bad quality, and the circumstance when discovered has not been otherwise attended to than by replacing the broken piece; but in many instances the phenomenon has been clearly established, closely examined, and well attended to, and that for years together, without, however, having become a generally acknowledged fact, sufficiently positive to justify the opinion that wrought iron, applied for certain purposes, ought only to be allowed to perform a previously deter-

mined quantity of work, after which it becomes requisite to re-forge the piece.

In most cases the fracture may be unattended with danger to human life, but in others, as in connexion with railways, where hundreds of lives may depend on the strength of an axle, it daily becomes more evident that extraordinary precautions must be resorted to for the purpose of avoiding accidents, and I would, with regard to railway axles, suggest (as a precautionary measure) the propriety of limiting the distance they should be allowed to run previous to their being thrown out as unfit for service, and that whether apparently in good condition or not. Such is the perfection with which these axles can now be manufactured, that when a suitable quantity of iron is used, it may be confidently asserted that every axle turned out of the shop after due examination may be considered to be sound, and that by limiting the work it is allowed to perform, the fracture of an axle would become a very improbable event.

Having been lately in Paris, I mentioned the circumstance to M. Arnoux, the directing manager of the extensive works belonging to the Messageries, Laffitte & Caillard, persuaded that from a person whose attention has been for so many years engaged on this subject, I should obtain some positive information; he showed me a number of axles which he had caused to be broken, after they had performed their allotted quantity of work; they all broke short and brittle, the fracture invariably indicating the progress of the disease. The fracture commences at the lower angle of the axle on the side of the traction, which is evidently, in fixed axles, the point of greatest fatigue, and in those axles which have given way under the weight of the load, the fissure has in some instances nearly traversed the axle before it broke entirely, and it is then very easy to trace the accident from its origin. I will endeavor to describe its usual appearance by the following diagram; the arrow shows the direction in which the carriage moves.



The fracture invariably originates at the angle *a*, and appears to progress at intervals by zones, as shown by the lines in the diagrams; the first, at the point *a*, becoming perfectly black, the color of each being lighter as they gradually extend from this point, and as the contact of the two sides of the fracture becomes more intimate, the grain of the iron towards the angle *a* is coarse, and has a large, crystaline texture, which diminishes in size as the fracture approaches the angle *b*, at which point the metal remains slightly fibrous, having evidently undergone a more rapid deterioration at its point of greatest strain.

M. Arnoux informed me, that in consequence of this effect, to which he has for a long time paid great attention, he has come to the conclusion that an axle can only safely run a distance of 30,000 leagues, or about 75,000 English miles; when an axle has run that distance, he invariably takes it out, places it between two new bars of iron, and welds them together so as to form a new axle. If the carriage usually runs over a paved road, such as is frequently met

with in France, the axle is not allowed to run so great a distance, and a certain degree of wear in the collar then determines the period at which the axle is thrown out; not in consequence of the wear of the collar, but because that degree of wear has proved, by experience, that it is prudent to renew the axles in order to avoid a fracture.

Here, then, we have the proof of an important principle in the application of wrought iron, being well established and long known to one, and probably to many, individually, without having come to the knowledge of railway engineers, who are thus compelled to arrive at this important truth by dint of actual experience, obtained through the medium of a series of lamentable accidents; and they could not acquire their information in any other way, unless made acquainted with the circumstance by those who have previously purchased their knowledge.

The question, then, admitting the above statement to be correct, will be, how great a distance it may be prudent to allow railway axles of different descriptions to run; and to solve this question, it will be advisable, in the first instance, to adopt a term which may certainly be within the limit of perfect safety, until the greatest distance that can be safely adopted may have been determined by a series of well conducted experiments.

Iron exposed to great heat undergoes the same kind of deterioration. I examined, in the same establishment, several bars taken from a furnace in which they heat their wheel hoops; the part of the bar directly exposed to the fire offered the same crystaline appearance as the broken axles, which gradually diminished towards the end that was out of the fire, and the end of the bar which was out of the fire altogether, had the appearance of good tough iron. The portion which had suffered most from its direct contact with the heat, having been doubled over and welded, entirely recovered its fibrous quality, and stood a cold bend as well as any iron that had been in the fire.

Should you find this communication worthy a place in the *Journal*, you will oblige, by its insertion,

Your obedient servant,

20th Jan., 1843. H. H. Edwards.

Civ. Eng. and Arch. Jour.

Use of Sulphate of Ammonia in Agriculture.

For the full development of the capacity of the soil, and to afford a greater amount of nitrogen than what is afforded either by the ordinary manure, or the ammonia, &c. of the atmosphere, sulphate of ammonia has been introduced, and found to be a most valuable auxiliary, as a top dressing, to the farmer.

It has been found to impart a greater degree of fructification to grass, wheat, and other grain, than any other dressing yet discovered, and at a less cost by 50 per cent.

The mode of application as adopted by Mr. C. Hall of Haveringatte-Bower, Essex, is as follows:—

Having selected several fields of grass, peas, turnips, and wheat, he had sown broadcast on parts of these fields quantities at the cost of 5*s.* 3*d.*, 11*s.* 4*d.* and 21*s.* per acre; the sulphate having cost him 17*s.* per cwt.

The produce was kept and threshed separately, when the increase from the wheat land was found to be as follows:—

The part that was sown at the rate of 5*s.* 3*d.* per acre gave an increase of 3 bushels; 11*s.* 4*d.* gave six bushels, and 21*s.* upwards of 9 bushels, besides a considerable increase of straw.

Philos. Mag.

Mechanics' Register.

Report from the Commissioner of Patents, showing the operations of the Patent Office during the year 1842.

PATENT OFFICE, *January*, 1843.

SIR: In compliance with the law of Congress, the Commissioner of Patents has the honor to submit his annual report.

Five hundred and seventeen patents have been issued during the year 1842, including *thirteen* re-issues, and *fifteen* additional improvements to former patents, of which classified and alphabetical lists are annexed, (marked B and C.)

During the same period, three hundred and fifty-two patents have expired, as per list marked D.

The applications for patents during the year past amount to *seven hundred and sixty-one*, and the number of caveats filed was *two hundred and ninety-one.*

The receipts of the office for 1842 amount to $35,790.96, from which $8,086.95 may be repaid on applications withdrawn, as per statement E.

The ordinary expenses of the Patent Office for the past year, including payments for the library and for agricultural statistics, have been $23,154.48, leaving a net balance of $5,264.20, to be credited to the patent fund, as per statement marked F.

The above expenditures do not include those incurred within the last year, for the recovery of the stolen jewels.

For the restoration of models, records, and drawings, under the act of March 3, 1837, $14,060.02 have been expended, as per statement marked G.

The whole number of patents issued by the United States, previous to January, 1843, was *twelve thousand nine hundred and ninety-two.* The continuance of the depression of the money market, and the almost universal prostration of all business, operate very disadvantageously on the receipts of this office, as many hundred applications are delayed solely from the want of funds or difficulty of remittance. The patents granted for the year, however, exceeded

those of the year previous by *twenty*, though there have been less applications by *eighty-six*.

The Digest of Patents, continued and brought down to January, 1842, has been printed, and 700 copies distributed to the respective States, and 200 copies deposited in the library, in compliance with the resolution of Congress directing the same.

The accommodations granted during the last year for the reception of the articles received through the exploring expedition, intrusted to the National Institute, must seriously thwart, if not suspend, the design of Congress in the reorganization of the Patent Office, which enacts, section 20, act of July 4, 1836, "that it shall be the duty of the Commissioner to cause to be classified and arranged, in such rooms and galleries as may be provided for that purpose, in suitable cases, when necessary for their preservation, and in such manner as shall be conducive to a beneficial and favorable display thereof, the models, and specimens of composition and fabrics, and other manufactures, and works of art, patented or unpatented, which have been or shall hereafter be deposited in the said office."

While the annual receipts of the Patent Office above the expenditures are sufficient to carry out fully the benevolent object of the National Legislature, the want of room of which it is thus deprived will be, for a time, an insurmountable obstacle, as all the room in the gallery could be advantageously used either by the Patent Office or the National Institute. No remedy, therefore, remains, but an extension of the building, which might be done by the erection of a wing sufficiently large to accommodate the Patent Office, on the first story. The building can also afford room for lectures by professors, should they be appointed under the Smithsonian bequest; and may I be permitted here to observe, that a gratuitous course of lectures in the different branches of science would certainly do much to diffuse knowledge among men. I can confidently say, that the agricultural class look forward with bright anticipations to some benefit from the Smithsonian bequest, and to the time when the sons of agriculturists, after years of toil at the plough, can attend a course of lectures at the seat of Government, and there learn, not only the forms of legistion, but acquire such a knowledge of Chemistry and the arts as will enable them to analyze the different soils, and apply agricultural chemistry to the greatest effect. Such encouragement will, indeed, stimulate them to excel in their profession, while others, deemed by many more favorable, are indulged with a collegiate course of education. Little, indeed, has been done for husbandry by the General Government; and, since eighty per cent. of the population are more or less engaged in the pursuit, the claim on this most beneficial bequest will not, it is hoped, be disregarded. The National Agricultural Society, in connexion with the Institute, will most cheerfully aid Congress in carrying out their designs, for the great benefit of national industry.

It is a matter of sincere congratulation, that the Patent Office has so far recovered from its great loss in 1836, by the conflagration of the building, with all its contents. A continued correspondence with

11,000 patentees, and untiring efforts on the part of all concerned with this bureau, have accomplished much; indeed, to appearance, the models are better than previous to the fire. Although something yet remains to be done, enough has been accomplished to remove the past embarrassment, and afford applicants the means of examination as to the expediency of applying for a patent.

The loss to the library, sustained by the fire, is not yet fully repaired; and, since the law of 1836 makes it a duty to examine all applications for patents, with reference, also, to foreign inventions, it is absolutely necessary that the library should be extended.

It is true that the library of Congress possesses some books on scientific subjects, useful for reference in the labors of this bureau, but no permission is given to take out books from that library; and, if such liberty were granted, it would be bad economy to send an examiner to the Capitol, to look up similar cases. If applications are to be examined, it will promote the despatch of public business, protect against spurious patents, and give public satisfaction, if the Patent Office library is well supplied with necessary books.

Already, hundreds of applicants are satisfied, by the comparatively imperfect examinations now made by referring to books on hand, not to take out a patent; and when, in the rejection of cases, reference is made to foreign patents, there is an impatient desire to see the description of the invention that is to cut off the hopes of so many years of toil and labor. I would therefore most earnestly recommend an appropriation of $1,200 from the surplus fund, to add to the Patent Office library.

The annual agricultural statistics, comprising the tabular estimate of the crops for the past year, with accompanying remarks and appendix, will be found subjoined, (marked A.)

The value of this document to the whole country, from year to year, it is believed, would justify a much larger appropriation from the Patent Office fund for this purpose. The diffusion of such information may save millions to the laborious tiller of the soil, besides adding directly to his means of export many millions more. An examination of this subject, and the expediency of fixing it on a more permanent and advantageous basis, by the constitution of an agricultural bureau, or at least an agricultural clerkship, at a moderate expense, to be drawn from the patent fund, is respectfully suggested. The additional benefit which might thus accrue to the population of our widely extended country would soon be seen.

A sufficient appropriation to allow a personal examination of the various parts of the country, by some one well qualified for such duty—similar to what has been attempted with so much success by some of the State Legislatures—would, it is believed, realize a vast amount of practical good, especially to the South and West, by furnishing the data on which they might direct their products to the best markets, for domestic sale or foreign export.

Such, indeed, are the great benefits to result from personal observation and critical examination, not only of the crops, but agricultural

implements—such the importance of explaining the new improvements, and collecting and distributing all the acclimated seeds, which are proved to be so signally productive or beneficial, that the Commissioner of Patents has doubted whether a modification of his duties, in connexion with the Patent Office, would not be more useful to the community. During the last year, he embraced the opportunity, while traveling, to examine the crops in ten States; and though the examination was of course imperfect, it enabled him the better to digest the somewhat discordant materials from which the agricultural statistics here incorporated were compiled. If millions can be saved to the public, if the agriculturalist can be encouraged in his all-important pursuits, by the expenditure of a small sum from the annual surplus of the patent fund, what better destination could be given to this amount? Would not the people heartily approve and earnestly second such an undertaking?

All which is respectfully submitted,

H. L. Ellsworth.

List of American Patents which expired in 1842.

Apples, machine for grating—U. Emmons, city of New York, Feb. 13.
Atmospheric Engine—E. A. Talbott, Dublin, Ireland, June 21.
Axle—D. Phillips, of Middlebury, and W. Mahar, Covington, New York, April 23.
Bands, metallic, communicating power—J. Eve, Augusta, Georgia, May 1.
Bark Mill—A. Bull, Caroline, New York, March 27.
——————J. Montgomery, Saugerfield, New York, May 29.
Barrels, Kegs, &c., machinery for making—Goodrich & Tainter, Waterbury, N. Y. June 9.
Bedsteads—S. Hyde, Arcadia, New York, May 2.
——————Swift & Ottiwell, N. Bedford, Mass., Oct. 11.
——————H. Wilbur, Newburyport, Mass., June 16.
—————— revolving rail and round tenons—G. Post, Auburn, New York, Oct. 11.
Bees, management of—F. Kelsey, Lockport, New York, Aug. 26.
Bellows—E. Brady, Mount Pleasant, New York, April 3.
Binnacle lamps—W. Lewis, Boston, Mass., June 24.
Blocks, snatch—J. Evans, Charlestown, Mass., Dec. 6.
——— used in stereotype printing—S. Goodrich, Boston, Mass., Oct. 11.
Boats for canals—B. Phillips, Philadelphia, Pa., April 21.
Bobbin machine—J. A. Post, Warwick township, New York, April 23.
——— and flyers for cotton speeders—C. Danforth, Ramapo, New York, Sept. 2.
Boilers for steam engines—J. P. Allaire, city of New York, May 14.
—————————— A. Potter, city of New York, Oct. 11.
——— for oil and refining sugar—W. A. Archibald, Baltimore, Md., May 29.
Boot for stages—P. Laporte, Augusta county, Va., July 28.
—— tree—J. Ayars, Brookfield, New York, Nov. 27.
———— H. B. Miller, Maysville, New York, Aug. 25.
Boxes for sugar, making, by machinery—Pearson & Home, Alria, Maine, April 15.
Brake, wagon, self-regulating—T. Turner, Ward, Mass., Aug. 29.
Brick machine—D. Rising, Colchester, N. Y., Jan. 29
—————— D. Flagg, Gardiner, Maine, March 19.
———————— on M'Donald's—M'Donald & M'Queen, city of New York, Nov. 19.
Brick press—E. & D. W. Duty, Painesville, Ohio, June 7.
—— and tile press—E. Mayo, Hallowell, Maine, Dec. 9.
—————— S. Parker, Gardiner, Maine, Nov. 29.
Buildings, covering—H. Knowles, Colchester, Conn., Oct. 10.
Cables, proving chain and hemp—J. Judge, Washington, D. C., Nov. 29.
Cannon lock, percussion—J. Shaw, Philadelphia, Pa., Oct. 24.

Carriage bodies—J. Reeder, Lebanon, Ohio, Nov. 4.
———, railway—R. Winans, Vernon, N. J., Oct. 11.
———, improvement in—T. Knox, Sniggersville, Va., March 15.
Casks, barrels, &c., making—W. & M. Adams, Ogden, N. Y., June 4.
——— ——— machine for making—J. Hale, Oakum, N. Y., June 21.
Cements, fire and water proof—J. Coburn, Middlesex county, Mass., Sept. 3.
Cheese press—Hitchcock & Stone, city of New York, July 24.
——— L. Martin, Grantsville, N. Y., Dec. 19.
Churn—S. H. Baker, Wells township, Pa., Jan. 10.
——— J. Hathaway, Canandaigua, N. Y., Aug. 22.
——— E. Spain, Mount Holly, N. J., April 23.
——— and washing machine—D. Read, Slatersville, N. Y., June 16.
——— J. Grout, Caroline, N. Y., Oct. 10.
——— R. R. Palmer, Caroline, N. Y., March 21.
Cloth machine, vibrating and napping—S. Duncan, Northampton, N. Y., Jan. 21.
——— manufacture—J. P. & R. G. Hazard, Providence, R. I., Dec. 6.
——— manufacturing—J. P. & R. G. Howell, Providence, R. I., Dec. 6.
——— shearing—J. & G. C. Kellog, New Hartford, Conn., April 7.
Collars for dress coats—H. Clark, Brooklyn, N. Y., Nov. 7.
Combs, machine for grailing—P. Pratt, Meriden, Conn., Feb. 12.
Compass, mariners', fixing—L. Langley, Gosport, Va., June 23.
Composition for roofs, fire and water proof—D. Greer, Pittsburgh, Pa., April 25.
Cooking apparatus—E. Bennett, Kingsbury, N. Y., Feb. 15.
——— stove—A. Fisher, Claremont, N. H., May 9.
——— D. G. Garnsey, Pomfret, N. Y., March 3.
——— R. C. Rouse, Athens, N. Y., Jan. 26.
Coopers' work, manufacturing—H. Waters, Watertown, N. Y., April 3.
Corn sheller—T. I. Deane, Virgin, N. Y., Dec. 8.
——— P. Grosjeane, Louisville, Ky., July 29.
——— W. Hoyt, Vernon, Ind., April 29.
Cotton gin feeder—J. Ewbank, Jr., Glasgow, Ky., July 29.
——— picker—Pennell & Maxon, Barboursville, Va., Oct. 10.
——— press—W. J. Cocke, Cabin Point, Va., Feb. 4.
———, spinning and twisting; J. Thorpe, Providence, R. I., Nov. 20.
Cough drops; D. E. Smith, Cornwall, Conn., June 30.
Cultivator; R. Herbert, Williamson co., Tenn., April 19.
Curriers' knife; J. H. Harrington, Albany, N. Y., June 26.
——— do. do. do. " 28.
Cutting cabbages; Berkeymeger & Dangler, Greenwich, Pa., Nov. 10.
——— rags; M. Y. Beach, Springfield, Mass., Oct. 18.
Distilling; Laws & Monteith, Louisville, Ky., July 30.
——— J. R. Nance, Floyd, Ind., Dec. 27.
——— by steam; B. Barr, Strasburgh township, Pa., April 5.
——— spirits; J. Hungus, Hempfield township, Pa., May 17.
——— ——— from still slops; D. White, Fredonia, N. Y., June 17.
——— spirituous liquors; W. J. Cocke, Cabin Point, Va., Feb. 4.
Dock; N. Saltonstall, New London, Conn., May 29.
Doors, constructing; D. Williams, Jr., Colchester, Conn., Oct. 14.
Drawing and corking sparkling liquors; S. A. Billie, city of New York, Nov. 8.
Dressing staves; L. Benton, Hanover, N. Y., July 12.
Dysentery, dyspepsia, &c.; T. Powell, Burlington, Vt., Feb. 2.
Dyewood and tan bark cutting, self feeding—A. Foster, Rochester, N. Y., Dec. 9.
Excavator, floating; H. W. Campbell, Lockport, N. Y., Jan. 22.
Fastenings for window shutters; T. Bartholomew, city of New York, Feb. 19.
Felloes; G. Andrews, Tolland, Conn., Oct. 24.
——— sawing and cutting; S. Fahrney, Washington co., Md., Dec. 9.
Fencing, repairing; E. Pitkin, East Hartford, Conn., Dec. 13.
Files, machine for cutting; J. Hatch, Roxbury, Mass., Oct. 10.
Filtering water; C. Hall, Norfolk, Va., Feb. 22.
——— J. S. Phillips, Philadelphia, Pa., Aug. 27.
Fire engine; E. Daboll, Canaan, Conn., April 12.
Flax, swingling; S. Ackey, Heidelberg township, Va., Feb. 18.
——— and hemp machine; E. Christian, Philadelphia, Pa., Feb. 8.

Flax and hemp machine; J. C. Wentzell, Louisville, Ky., Jan. 17.
Flutter wheel, application of water to; J. Stewart, Robertson county, Tenn., Oct. 24.
Forcing pump, quadruple; J. Ferris, Ellicott, N. Y., Aug. 12.
Furnace, iron; B. B. Howell, Philadelphia, Pa., Oct. 14.
———, steam, for anthracite coal; B. B. Howell, Philadelphia, Pa., Oct. 14.
Gas, inflammable during the combustion of anthracite coal; Ward & Hall, Baltimore, Md., Jan. 19.
Gates for locks of canals; D. Rogers, Little Falls, N. Y., Jan. 14.
Generator, tubular, steam; B. R. Throckmorton, city of New York, Jan. 17.
Glass knobs; T. B. & J. P. Bakewell, Pittsburgh, Pa., March 14.
——, melting and fusing; T. W. Dyott, Philadelphia, Pa., Oct. 10.
——, moulding, &c.; D. Jarvis, Boston, Mass., Dec. 1.
Gold and silver, separating from the earth; W. H. Folger, Spartanburgh, S. C., Feb. 13.
Gout nostrum; E. Smith, city of New York, Dec. 15.
Grist mill; J Crarl, Warren, Ohio, June 19.
——— S. Holland, Hanover, Ohio, March 1.
——— R. Medley, Bloomfield, Ky., Sep. 5.
——— Smith & Sapp, Mount Vernon, Ohio, Sep. 9.
——— W. L. Taylor, McMinn, Tenn., Jan. 28.
——— A. Warren, Saugerties, N. Y., March 12.
Gum, extracting from unrolled flax; S. Olcott, Harsimus, N. J., Dec. 3.
Hammer, cast iron; T. Jones, Glastonbury, Conn., July 31.
——— for cutting and dressing granite; J. Richards, Braintree, Mass., Feb. 20.
Hat bodies; West & Stevens, Richland, N. Y., Oct. 29.
———, machinery for manufacturing; G. L. Thatcher, Brooklyn, N. Y., May 31.
Hatters' carding machine; J. Sandford, Blockley, Pa., Oct. 10.
Hay presses; M. B. Bliss, Pittstown, Maine, Jan. 26.
Heat, evolving and management of; E. Nott, Schenectady, N. Y., March 26.
——, production of; S. A. Bille, city of New York, Nov. 8.
Hemp brake; J. S. Vandergriff, Scott co., Ky., May 12.
——, preparation of; A. K. Smedes, Lexington, Ky., Oct. 11.
Hides, tanning and manufacturing; Shove & Hunt, Locke, N. Y., May 13.
Hoops, laths and staves, sawing; I. Price, Jr., Lockport, N. Y., Aug. 19.
———, machine for sawing; P. Slayton, Lockport, N. Y., May 1.
Horse, improving the shape of; A. Carman, Hyde Parke, N. Y., Nov. 27.
——— mill, lever; J. Galbraith, Maury co., Tenn., March 6.
——- shoes; R. E. Hobert, Pottstown, Pa., May 24.
Hose, &c.; J. A. Black, Columbia, S. C., Oct. 13.
Hubs and axletree; P. Slayton, Lockport, N. Y., Oct. 27.
——, cast iron; W. Dickerman, Batavia, N. Y., Oct. 6.
——, herculean carriage; H. Thomas, Medway, Mass., Feb. 8.
Hydrant fountain; L. Gauley, Philadelphia, Pa., Aug. 1.
Hydraulic elevator; J. M'Creery, Nobletown, Pa., Jan. 5.
——— engine, revolving; A. Hubbard, Windsor, Vt., April 22.
——— machine; W. Barker, Wilkesbarre, Pa., Aug 26.
Incline plane for raising and lowering canal boats; W. Knight, Morristown, N. J., Aug. 5.
——— transporting; M. Robinson, Henrico co., Va., April 9.
Ivory, machine for junking; Pratt & Bush, Meriden, Conn., Feb. 9.
Jackscrew for raising wagons; H. Salisbury, Springfield, Mass., March 8.
Lamp, signal; Feinour & Son, Philadelphia, Pa., Aug. 1.
——, safety compass; do. do. do. April 5.
Lathe, turning; J. Moore, Leverett, Mass., Jan. 19.
——, wheelwrights' felloe; Sitton & Black, Pendleton and Columbia, S. C., May 5.
Laths, &c., splitting; B. K. Crandell, Lockport, N. Y., Aug. 25.
——— and other timber, manufacturing—L. Rice, Lockport, N. Y., July 23.
Leather, belt and picker, preparing—J. J. Travis, Franklin, Conn., Oct. 22.
——— and cloth, water proof; T. L. Comstock, Hartford, Conn., Jan. 21.
———, machine for cutting; G. P. Mitchell, Burlington, N. J., May 15.
——— rolling machine; S. A. Brownson, Montrose, Pa., Dec. 26.
——— H. Paign, Alexandria, Miss., Dec. 23.
———, water proof; A. Straub, Milton, Pa., June 30.
Lever press; Wm. Linn, Danville, Va., April 25.
Lock, percussion; J. Caswell, Manlius, N. Y., May 8.

Locks, percussion; J. Lawrence, New Berlin, N. Y., May 24.
——— water proof, self-priming; S. L. Faries, Middletown, Ohio, May 29.
—— wagon; J. M. Davidson, Brownsville, Pa., April 14.
—— ——— George Divan, Franklin co., Pa., April 14.
Locomotive engine; W. Howard, Baltimore, Md., Dec. 10.
Longimeter; A. Bayard, South Reading, Mass., July 16.
Loom, power, check and plaid; Burt & Boyds, Manchester, Conn., Aug. 19.
—— sattinet, power; L. Marble, Henrietta, N. Y., June 22.
——————— Mitchell & Butterworth, Troy, Mass., June 22.
Lotteries; J. J. Cohen, Baltimore, Md., Aug. 26.
——— drawing; W. E. Spalding, Brooklyn, Conn., Feb. 15.
Marble, sawing, cutting, and polishing; A. M'Alister, Salem, N. Y., Feb. 18.
Mats, from Manilla and other grass; S. S Williams, Roxbury, Mass., Aug. 22.
Medicine; F. Bird, Hancock, Ga., April 16.
——— J. Dent, Augusta, Ga., July 2.
Morocco, polishing, graining, and dicing; A. Bayard, South Reading, Mass., Dec. 29.
Mortising and tenoning machine; Jackson & Speed, Jr., Speedville, N. Y., Oct. 10.
——— machine; J. J. Kellog, Richmond, N. Y., Jan. 24.
——————— W. E. March, Westfield township, N. J., April 18.
Mule drums, grooving; J. Butterworth, Philadelphia, Pa., Dec. 30.
—— for spinning cotton; T. Walker, Chester co., Pa., June 26.
Nails, wrought; H. Burden, Troy, N. Y., May 26.
Oil, pressing, from flaxseed; How, Brewster & Johnson, Newton, Colchester, and Chittenden, Vt., May 24.
Oven for baking over a cooking furnace; E. Moody, Northfield, Mass., April 5.
—— portable; F. L. Hedenburgh, city of New York, April 26.
Oyster platform; J. Freeland, city of New York, Oct. 29.
Paddle gate; J. F. King, Watertown, N. Y., Nov. 29.
Paint for plastered walls; A. Thompson, Bethany, N. Y., Feb. 2.
Paper, manufacturing; A. & M. A. Sprague, Fredonia, N. Y., Oct. 31.
——————— W. Magaw, Meadville, Pa., March 8.
——————— machine; Waterman & Annis, Providence, R. I., Aug. 30.
—— making, by the flat press; M. Haddock, city of New York, July 17.
——, preparing straw, hay, &c., for making; W. Magaw, Meadville, Pa., May 22.
——, top press roller for making; M. Hunting, Watertown, Mass., Oct. 20.
Pen microscopic machine; J. Bennett, Lowell, Mass., Oct. 11.
Peg cutting machine; H. Thurber, Painted Post, N. Y., May 22.
Piano fortes; C. F. L. Albright, Philadelphia, Pa., March 28.
——— fitting hammer heads to; J. Mackay, Boston, Mass., Aug. 14.
Pill, rheumatic; E. Dean, Biddeport, Mass., Feb. 2.
Pipes, leaden, testing; T. Packard, Sherburn, Mass., April 28.
—— of clay; T. Wickersham, Newbury, Pa., May 13.
Planting grain, machine for; O. Starr, Richmond, N. Y., Aug. 22.
——— machine; A. H. & L. Robins, Denmark, N. Y., Aug. 28.
Plough; J. Deats, Middletown, Pa., April 26.
——— R. Loveridge, Knox co., Ohio, March 8.
——— S. M'Cormic, Fauquier co., Va., Oct. 22.
——— W. Wiard, city of New York, Jan. 26.
———, bar share; J. Deakyns, Petersburg, Va., Nov. 18.
———, hill side; N. Staples, Penn's Grove, Va., Nov. 1.
Plugs, cutting, for decks and waists of ships; J. Josselin, city of New York, May 3.
Press frame, improvement on Brown's; R. Hoe, city of New York, April 22.
Pressing horn for combs; U. Bailey, West Newbury, Maine, Feb. 2.
Printing press; Holbrook & Thomas, Brattleboro', Vt., Feb. 7.
———————, copperplate; C. Durand, city of New York, May 22.
———————, cylindrical; C. G. Williams, city of New York, May 29.
——————— roller; G. W. Cartwright, Mount Pleasant, N. Y., April 29.
——————— J. Laird, Pittsburgh, Pa., Aug. 16.
Propelling boats by hydraulic apparatus; B. Phillips, Philadelphia, Pa., Aug. 16.
——————— spring and main value; W. Willis, Charleston, S. C., May 2.
——— ships, &c.; A. Hermange, Baltimore, Md., May 31.
——————— do. do. do. do. Nov. 26.
——————— do. do. do. " 26.

Propelling vessels; H. Case, Norwalk, Ohio, Aug. 13.
Pump, applying power to common; N. Underwood, Baltimore, Md., July 17.
——— boxes; Williams & Rice, Salem, Mass., Dec. 9.
——— for beer, soda, water, &c.; L. Pitkin, Rochester, N. Y., Oct. 11.
——— logs, boring; G. W. Draper, Camillus, N. Y., March 31.
———, tide basin; G. M. Seldon, Troy, N. Y., March 10.
Punching copper; W. Ballard, Boston, Mass., Dec. 6.
Railway car; W. Howard, Baltimore, Md., Nov. 22.
———, submarine; J. Thomas, city of New York, Nov. 6.
Raising, &c., canal boats, without locks; W. Wiard, city of New York, March 1.
——— water by steam; J. S. Fox, Otto, N. Y., April 5.
——— from wells; S. Smith, Mendon, N. Y., Aug. 20.
Reaping machine; S. Lane, Hallowell, Maine, Aug. 8.
Reel for handling hides; W. Brown, Frankford, Pa., April 17.
Rice, machine for cleaning; J. Ravenal, Charleston, S. C., May 17.
——— thrashing machine; W. Warren, city of New York, Feb. 22.
Rifle, double shooting; Mosher & White, Hamilton, N. Y., May 5.
Rocks, boring; J. Overall, Liberty, Tenn., March 14.
Rope reeding machine; Boring & Jones, Thornville, Ohio, May 5.
Rosin, pine, for fuel; R. L. Wood, Philadelphia, Penn., Oct. 10.
Rotary steam engine; S. Blake, Providence, R. I., Oct. 11.
Ruler, triangular measurer; A. Ward, Philadelphia, Pa., Oct. 11.
Ruling paper; C. Lanuza, city of New York, Aug. 13.
Saddle spring; T. Harvey, Middletown, Del., Jan. 24.
Saddles; A. Marshall, Pikeland township, Pa., April 30.
Sausage cutter; S. Fahrney, Washington co., Md., Dec. 9.
Saw, circular; L. B. Bumb, Wareham, Mass., Aug. 29.
———————, for clap boards; J. Kidder, Gorham, Me., Oct. 11.
——— frame, armed; N. Sperry, Nashville, Tenn., June 18.
——— mill; J. Call, Woodstock, Conn., April 28.
——— curvilinear; D. Baker, Ipswich, Mass., Aug. 7.
Sawing hoops; N. Brutt, Lockport, N. Y., July 31.
Screen, zigzag; J. Woodhull, Rochester, N. Y., Dec. 31.
Screws, archimedean; P. Harris, Preble co., Ohio, March 25.
———, arranging machinery for making; S. Wright, London, Eng., Dec. 6.
———, machine for cutting wooden; S. Treadwell, Western, Conn., May 22.
Scythe snathe; S. Lamson, Sterling, Mass., Dec. 29.
Self-loading car; W. Beach, Philadelphia, Pa, Feb. 5.
Shingle machine; How & Chaffin, Holden, Mass., May 22.
——— D. Wilder, Rome, N. Y., Aug. 25.
Shingles, sawing; C. Read, Western, Mass., April 2.
Shovels, scythes, &c., of cast steel and iron; E. A. Bulkley, Colchester, Conn., Feb. 28.
Shuttle for tying knots; J. Thorp, Providence, R. I., Nov. 20.
Slates, machinery for making; T. Symington, Baltimore, Md., Nov. 17
Sleigh shoes, cast iron; I. Arnold, Oswegatchie, N. Y., March 12.
Smut machine; T. Carpenter, Elmira, N. Y., Dec. 4.
Spine, infected, apparatus for; J. K. Casey, city of New York, June 23.
Spinner, domestic; E. Penney, Adams, N. Y., June 27.
——— ring groove; J. Thorp, Providence, R. I., Dec. 31.
Spinning and roping cotton wool; J. W. Wheeler, Galaway, N. Y., Oct. 11.
——— of filling, or slack twisted, yarn; J. Thorp, Providence, R. I., Nov. 29.
——— wool, flax, and hemp; T. T. Abbott, Greenland, N. H., Feb. 26.
——————— and cotton; A. Critchfield, Union township, Ohio, April 24.
——————— E. H. Collier, do. do. " 24.
Steam, application of; J. Skinner, Mantua, Ohio, March 14.
——— boats for canals; J. F. Wright, Erie, Pa., Feb. 14.
——— boilers; A. Hermange, Baltimore, Md., Nov. 26.
——————— S. M. Richards, Chagrin river, Ohio, Aug. 21.
——————— for stone coal; J. G. Wilson, city of New York, Feb. 22.
——— engine; E. Broadmeadow, do. Jan. 27.
——————— P. Cooper, do. April 28.
——————— attaching tubes to; G. Freeborn, do. July 8.

Steam engine and steam power; W. Willis, Charleston, S. C., Feb. 1.
————, high pressure safety; I. Jennings, city of New York, Feb. 11.
————, specific; A. S. Kirk, Smithfield township, Ohio, Feb. 13.
——, gas, or vapor, generating; E. A. Lester, Boston, Mass., March 10.
Still, boilers, kettles, &c., setting; Miller & Clemmons, Clemmonsville, N. C., June 24.
Stone, making artificial; M'Kay, M'Kenzie & Woodhull, Caledonia, N. Y., Jan. 16.
Stove, Franklin; W. Cowden, Watertown, N. Y., June 16.
Stoves, chimnies, furnaces, &c.; J. J. Geraud, Baltimore, Md., Feb. 10.
Straw, Leghorn, &c., whitening; H. Cooper, Washington township, Pa., Nov. 12.
—— cutter; W. Cummings, Livingston co., N. Y., Feb. 11.
Sugar, filtering apparatus; W. A. Archibald, Baltimore, Md., May 29.
—— refining, double boiler, &c.; do. do. " 29.
Tables, breakfast and dining; P. Baker, Worthington, Ohio, Aug. 6.
Teeth, terro-metallic; A. Plantou, Philadelphia, Pa., April 5.
Threshing machine; S. L. Allen, Skaneateles, N. Y., Nov. 1.
———————— J. H. Barnet, Aurelius, N. Y., April 10.
———————— M. Barney, Nantucket, Mass., Aug. 5.
———————— N. Case, New Granville, Ohio, May 23.
———————— C. Emmons, city of New York, April 17.
———————— S. Felton, Kilbuck, Ohio, July 22.
———————— M. First, Uniontown, Md., March 3.
———————— E. Hoit, Charleston, S. C., Feb. 18.
———————— W. Loomis, Springfield, N. Y., March 6.
———————— Post & Byan, New Baltimore, Va., Oct. 10.
———————— for rice; W. Warren, city of New York, Feb. 22.
Tobacco, curing; M. & T. Baker, Louisa co., Va., March 4.
Tongs, cast iron; E. H. Buill, Marleborough, Conn., March 6.
Transporting and conveyance machine; J. J. Reekers, Baltimore, Md., July 21.
Trip hammer; L. Rosencrans, Big Falls, N. Y., March 17.
Types, casting printers'; W. Johnson, city of New York, Aug. 21.
———————— machine for; G. F. Peterson, do. Oct. 13.
Veneer saw frame; B. Crehore, Milton, Mass., May 22.
Vice for slitting iron; P. Pratt, Meriden, Conn., Feb. 12.
Washing, filling, and corking bottles; S. A. Bille, city of New York, Nov. 8.
——— machine; A. Bull, Cawline, N. Y., March 28.
———————— J. R. Davis, Hartland, N. Y., Sep. 2.
———————— G. Hancock, Maysville, Ky., May 24.
———————— J. & R. Hathaway, Pultney, N. Y., Sept. 5.
———————— M. Parker, Lowville, N. Y., May 1.
———————— S. Willard, Jr., Cincinnati, Ohio, Aug. 2.
————————, Leavitt's; E. M. Gibbs, Chenango co., N. Y., May 1.
————————, rotary; C. Post, Springport, N. Y., July 15.
——— and churning machine; J. Grout, Caroline, N. Y., Oct. 10.
———————————— R. R. Palmer, do. March 21.
———————————— D. Read, Slatersville, N. Y., June 16.
——— and pressing machine; H. Averill, Richland, N. Y., Aug. 14.
Washstand; J. Williams, Baltimore, Md., March 15.
Water, mode of obtaining; T. Davis, Lawrence, Ind., April 14.
—— pressure for propelling machinery; G. M. Gibbs, Williamsburg Dis., S. C., March 10.
—— power, increasing by atmospheric pressure; S. L. Holmes, Westchester, N. Y. Dec. 8.
—— wheel; J. Bell, Sycamore Spring, Ohio, May 9.
———————— A. Greenleaf, Mexico, N. Y., June 5.
———————— J. Torry, Ravenna, Ohio, Feb. 28.
———————— O. Thompson, Jericho, Vt., Dec. 6.
————————, hinged; M. D. Brown, Mason co., Va., Dec. 19.
————————, screw; E. Beard, Charleston, Mass., Jan. 25.
————————, spiral; J. Kelly, Jackson co., Ohio, Feb. 21.
Ways for drawing up vessels; A. Miller, New London, Conn., July 7.
Wicks, cotton yarn; G. Dickenson, city of New York, Feb. 21.
Windmill; A. Murray, Athens, Pa., July 8.
——— horizontal; W. Ingals, Sanbarton Bridge, N. H., Aug. 19.
Windlass; S. Nicholson, Boston, Mass., Dec. 1.

Window blinds; J. Parkerson, Boston, Mass., Oct. 11.
——— fastenings; H. Seeley, Unadilla, N. Y., July 14.
——— sashes, cast-iron; J. M'Nary, Stafford, Conn., Feb. 23.
———, blinds, &c.; J. Richards, Elbridge, N. Y., Nov. 12.
Wire cutting machine; A. Stevens, Andover, Mass., Nov. 11.
——, harness for weaving; E. Brown, Cazenovia, N. Y., Oct. 20.
Wool and cotton, spinning from the roll; W. R. M'Ball, Vincennes, Ind., May 12.
—— carding machine; H. A. Shannon, Columbia co., N. Y., April 5.
Wringing dyes, &c., out of cloths, &c.; W. Nelson, Batavia, N. Y., Nov. 13.
Yards of vessels, suspending; S. A. Wells, Boston, Mass., Jan. 23.

Meteorological Observations for December, 1842.

Moon.	Days.	Therm. Sun Rise.	Therm. 2 P.M.	Barometr. Sun Rise.	Barometr. 2 P.M.	Wind. Direction.	Wind. Force.	Water Fallen in rain	State of the Weather, and Remarks.	
⊗	1	27°	32°	29.56	29.65	W.	Blustering		Cloudy.	Cloudy.
	2	28	34	30.06	30.15	W.	Moderate		Cloudy.	Clear.
	3	32	48	29.73	29.73	W.	do		Cloudy.	Clear.
	4	38	44	29.83	29.80	SW.	do		Cloudy.	Cloudy.
	5	39	46	29.75	29.75	E.	do	.25	Cloudy.	Rain.
	6	30	35	30.15	30.20	NE.	do		Cloudy.	Par. cloudy.
	7	31	35	30.15	30.06	E. W.	do		Sleet.	Cloudy.
	8	32	33	29.96	29.85	NE	do	1.35	Rain.	Rain.
☾	9	35	43	29.50	29.50	NW.	do		Cloudy.	Cloudy.
	10	32	35	30.10	30.15	W.	do		Cloudy.	Cloudy.
	11	31	35	30.15	30.05	E. W.	do		Cloudy.	Cloudy.
	12	30	40	30.13	30.15	NW. NE.	do		Cloudy.	Cloudy.
	13	26	33	30.00	29.75	NE.	do	.36	Snow.	Rain.
	14	29	32	29.62	29.80	W.	do		Cloudy.	Cloudy.
	15	27	33	30.20	30.25	W.	do		Clear.	Flying clouds.
	16	22	33	30.10	30.10	W.	do		Clear.	Clear.
☉	17	38	40	29.50	29.50	W. SW.	do		Clear.	Lightly cloudy.
	18	24	38	29.80	29.70	W.	do		Cloudy.	Clear.
	19	26	42	30.00	30.03	W.	do		Clear.	Clear.
	20	34	38	29.80	29.50	NE.	do	.60	Cloudy.	Rain.
	21	39	40	29.36	29.40	W.	do		Cloudy.	Cloudy.
	22	18	26	30.30	30.30	W.	do		Clear.	Clear.
	23	14	24	30.30	30.40	W. SW.	do		Clear.	Clear.
☽	24	24	32	30.40	30.40	W.	do		Cloudy.	Cloudy.
	25	26	33	30.40	30.41	W.	do		Clear.	Cloudy.
	26	26	40	30.40	30.37	W.	do		Clear.	Clear.
	27	32	36	30.35	30.25	W.	do		Cloudy.	Cloudy.
	28	28	36	29.80	29.80	N.	do		Clear.	Clear.
	29	25	34	29.50	29.85	E.	do		Cloudy.	Snow.
	30	24	34	29.40	29.44	W. SW.	do		Clear.	Cloudy.
⊗	31	24	28	29.63	29.85	W.	do		Par. cloudy.	Clear.
		28.74	35.87	29.93	29.94			2.56		

Thermometer. Maximum 48 on 3d. Minimum 14 on 23d. Mean 32.305

Barometer. Max. 30.41 on 24th & 25th. Min. 29.36 on 21st. Mean 29.93

Errata in Vol. IV.

Page 150, line 17, for "*another*," read "*or other.*"
" 372, " 16, " "*italics*," " "*detail.*"
" 372, " 38, " "100," " "110."
" 374, " 17, " "*on*," " "*or.*"
" " " 26, " "*catching*," " "*arresting.*"
" " " 34, " "*could*," " "*would.*"
" 375, " 20, " "*as local*," " "*at local.*"
" 377, " 6, " "*reservoir*," " "*resources.*"